



# Legacy Nature Preserve

## **Comprehensive Water Management Plan**

**February 2007**



**LEGACY NATURE PRESERVE**

**COMPREHENSIVE WATER MANAGEMENT PLAN**

Submitted to

**Utah Department of Transportation**

4001 South 700 East, Suite 450  
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In Compliance with Section 404 Permit #200350493

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# **1.0 INTRODUCTION**

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## **1.1 SCOPE AND RATIONALE**

The Legacy Nature Preserve (LNP) Comprehensive Water Management Plan (CWMP) is a guidance tool for managing the acquisition, diversion, and application of the water resources available within the boundaries of the LNP for the preservation and improvement of the LNP's ecological functions (Figures 1–3). These water resources are to be managed to support the habitats outlined in the Habitat Management Plan (HMP; see Chapter 2 for a complete listing and description of habitats). The maintenance of high-quality wetland and upland habitats are principal goals of the HMP, thus management of water within the LNP is paramount to the success of habitat creation, enhancement, restoration, and sustainability. Monitoring of timing, amount, and quality of water distributed on the LNP in relation to ecosystem response will ensure water application methods are best suited to achieve goals outlined in the HMP. The CWMP outlines the water features and monitoring techniques available to the LNP Manager for these purposes.

## **1.2 GOALS/OBJECTIVES**

The goals and objectives of the CWMP were outlined in the Adaptive Management Plan (AMP) as part of a collaborative design process with input from agencies and individuals. Those involved include the U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service (USFWS), Utah Division of Wildlife Resources, Utah Department of Transportation, concerned citizen groups, and others. The AMP called for the development of resource management plans, which include the HMP, the access and education plan, and this document, the CWMP. These plans were all designed to evaluate resources and determine the proper techniques of ecosystem management that will support the natural processes and ecosystem services provided by the LNP.

The CWMP serves three purposes:

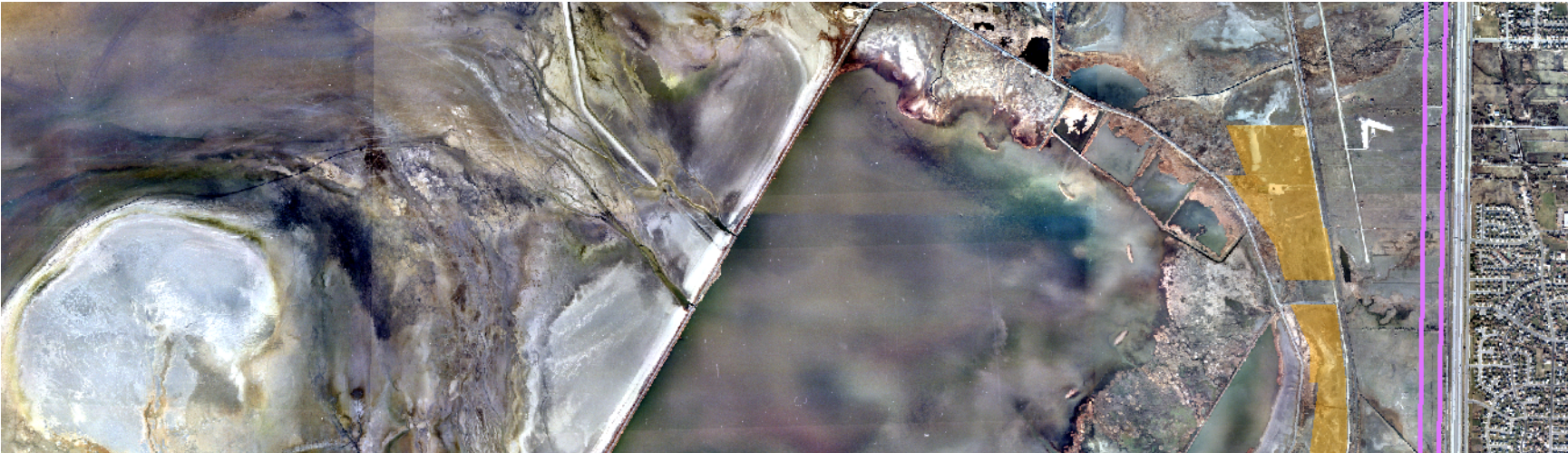
1. to serve as a guide for management of the available water resources;
2. to provide a framework for data collection and analysis;
3. and to support the evaluation and adaptive management outlined in the HMP.

Water management goals and objectives relating to specific ecosystem functions are based upon the resource needs described in the HMP. Specific water management goals and objectives identified in the HMP include protecting and enhancing water quality and ensuring adequate quantities of water are available to sustain wetland habitat functions. These and other water management goals and objectives are intended to support the habitat management objectives outlined in the HMP, including maintaining upland habitat and providing a dynamic and diverse habitat for bird foraging, resting, and nesting.

Like the HMP, the CWMP provides success criteria to determine if the water resources associated with the LNP are being successfully managed in order to achieve the desired outcome.



**Figure 1. Regional and local overview of Legacy Nature Preserve (LNP) near Great Salt Lake (GSL).**



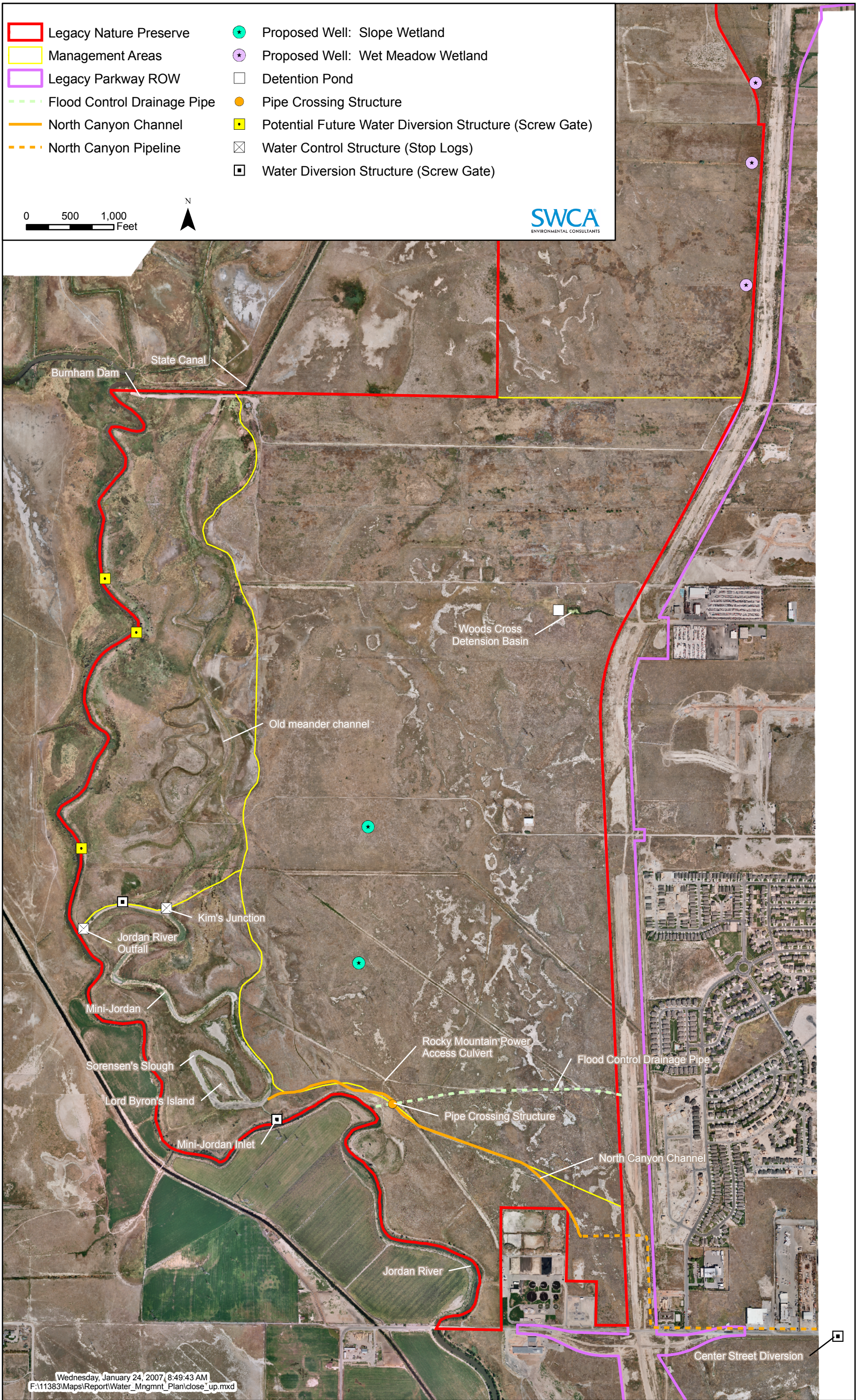


Figure 3. Closeup of the southern portion of the LNP and its water management features.

If it is determined the desired outcomes are not being achieved, the CWMP also provides a framework for successive adaptive management strategies.

### **1.3 LEGAL MANDATES/REGULATORY FRAMEWORK**

The legal mandates outlined in the USACE Section 404 Permit #200350493 require UDOT to maintain, enhance and/or restore wetland habitat on the LNP. Requirements include the restoration/ enhancement of wetlands within the Jordan River floodplain and creation of twelve acres of slope wetlands. The permit outlined the required maintenance, enhancement, or restoration of these wetlands. The CWMP is designed to provide a means for assessment and monitoring of water quantity and quality to support the goals and objectives detailed in the HMP.

The Utah Department of Environmental Quality (UDEQ) is the state environmental quality agency. Within this department is the Division of Water Quality (UDWQ), which has oversight of water quality of river, streams, wetland, and stormwater statewide including waterbodies within and around the Legacy Nature Preserve. The Utah Water Quality Act is the legislative action used for the development of the Rules associated with water quality within the State of Utah (UDEQ 2006).

The Utah Department of Natural Resources (UDNR) houses the Division of Water Rights (UDWR), the agency that has oversight of the appropriation of surface water and groundwater resources that are diverted and applied for beneficial use within the boundaries of the LNP. Rules associated with the Doctrine of Prior Appropriation and water use within Utah are Utah Code, Title 73, Chapter 2.

### **1.4 RELATIONSHIP TO OTHER PLANS**

The goals and objectives of this CWMP have been developed to support the HMP, Access and Education Management Plan (AEMP), and the management of the LNP. The HMP outlines water requirements that are specific to priority species' habitat needs (e.g., depth and duration of flooding), as well as the use of water to manage invasive species. In concert with the HMP, the CWMP details the physical aspects of how the HMP goals and objectives can be achieved through the passive and active manipulation of water resources available on the LNP. The AEMP provides guidance on how to manage access and education in order to uphold the mission of the LNP and ensure that the goals of the HMP and CWMP are not hindered by public access.

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## **2.0 LEGACY NATURE PRESERVE (LNP) WATER RESOURCE CHARACTERISTICS AND MANAGEMENT**

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The water features on the LNP include natural and enhanced surface flow features, flow control structures, and irrigation pipes connected to artesian wells (Table 1). These features will be tested to determine the availability of water resources for use on the LNP and the amount of water needed to sustain/enhance habitats outlined in the HMP. By monitoring the distribution and depth of the water and vegetation and avian responses, the LNP Manager will be able to determine the best use for water rights presently acquired by UDOT for use on the LNP.

The LNP has been divided into five separate management areas (MAs) based upon general habitat type and adjacency to the Jordan River (see Figure 2):

1. Evaporative Basins MA
2. Riverine MA
3. Alkaline Flats & Slope Wetlands MA
4. Wet Meadows MA
5. Farmington Bay MA

The surface flow features and control structures available for water management are primarily in the Evaporative Basins and Riverine MAs (see Figure 3). The artesian wells and irrigation pipes will be installed and utilized on the Alkaline Flats & Slope Wetlands MA and Wet Meadows MA. The water levels in the Farmington Bay Waterfowl Management Area (FBWMA) will provide the only means of manipulating water levels in the Farmington Bay MA. Some surface water features are also present in the Farmington Bay MA, but these will not be actively managed.

The LNP Manager may work with managers of the FBWMA to alter water levels in the Farmington Bay MA, but will have no ability to control water levels; thus limited discussion of FBWMA is included. Typical seasonal fluctuations of Great Salt Lake (GSL) surface elevations have no influence on water management within the LNP. However, during flood conditions (e.g. lake levels exceeding 4,212'), much of the LNP would be under water and LNP water management strategies and facilities would have no effect.

## **2.1 WATER SOURCE CATEGORIES**

The three major water sources available for use on the LNP include the North Canyon Watershed, the Jordan River, the Duck Clubs and the FBWMA. The primary sources of water for the Evaporative Basins MA and Riverine MA are the North Canyon Watershed and the Jordan River, which are discussed in detail as part of this plan. The primary water sources for the Alkaline Flats & Slope Wetlands MA and Wet Meadows MA will be artesian wells, where water will be supplied by the deep regional groundwater aquifer. FBWMA eastern ponds the Duck Clubs are the primary water features in the Farmington Bay MA and will not be controlled by the Manager; thus only a brief discussion of the Farmington Bay MA is included here.

### **2.1.1 NORTH CANYON WATERSHED**

The North Canyon Watershed flows into the North Canyon Channel and will provide the primary water for restoration, enhancement and maintenance of habitats within the Evaporative Basins MA and Riverine MA (see Figure 3). A number of structures have been installed within these MAs to control water entering and leaving the existing habitat features which include the Mini-Jordan Channel and Sorensen's Slough. Specific adjustment and monitoring of these structural features is discussed in Chapter 3, and measurement of flows at specific structures is detailed in Appendix A.

The North Canyon Watershed includes the area from the top of the Wasatch Mountains to the urbanized areas east of the LNP. This watershed has not been extensively studied, thus actual water amount and timing for runoff within the drainage are unknown. The structural features that control water entering habitat features within the LNP will provide the Manager the ability to control water levels and extent of inundation in these features. The flows will be measured and relations to inundation levels will be determined through techniques outlined in this plan.

### **2.1.2 JORDAN RIVER**

The Jordan River (Figure 4) is one of the major surface water tributaries to GSL and is a potential source of water for habitat features within the LNP. The river segment in the LNP is also within the FEMA 100-year floodplain of GSL, which flooded during historical lake high stands in the 1980s.



**Figure 4. Overview photograph of the Jordan River.**

Table 1. Water Sources and Diversions

MA	Name	Type	Source	Water Availability	Water Rights	Capacity	Actions	Details
Riverine	North Canyon Diversion at Center Street	Screw-gate diversion	North Canyon Creek at Center Street Diversion.	Higher flows during spring runoff; baseflow = 1-2 cfs.	Rights to all water from runoff, up to 14,160 acre-feet.	Up to 20 cfs.	Open screw-gate to allow water to flow into North Canyon Channel. Measure water passing through Utah Culvert and level of Jordan River outflow (see Appendix B). Check water quality.	Can be opened to allow water to flow through North Canyon Channel and through pipe crossing structure.
	North Canyon Channel	Open channel	North Canyon Creek at Center Street Diversion.	Runoff timing and amount to be tested.	N/A	TBD	Measure flow rates and water quality.	Used to measure North Canyon flow with height of Jordan River outlet and water surface at the upstream end of the Rocky Mountain Culvert.
	Mini-Jordan Channel	Open channel	North Canyon Channel through pipe-crossing structure.	Runoff timing and amount to be tested.	Refer to North Canyon Diversion and Mini-Jordan Inlet.	TBD	Measure aerial extent of water coverage.	Open water habitat feature.
	Mini-Jordan Inlet	Screw-gate diversion	Jordan River.	Dependent upon water level in Jordan River.	9.45 acre-feet Faye Jensen water and/or 48 acre-feet North Point.	~2 cfs.	Open screw-gate to allow water to flow into MA from Jordan River.	Water diversion structure along Jordan River.
	Jordan River Outlet	Stop-log structure	Mini-Jordan Channel.	N/A	N/A	N/A	Add or remove logs depending upon desired water level in Mini-Jordan Channel.	Controls depth of water in Riverine MA. Allows water from the Mini-Jordan Channel to flow back into Jordan River.
Evaporative Basins	Sorensen's Slough	Open water	Mini-Jordan Channel.	See North Canyon Channel.	Refer to North Canyon Channel.	TBD	Measure aerial extent of water coverage.	Open water habitat feature.
	Rocky Mountain Power Access Culvert	Culvert	North Canyon Channel, through culvert.	N/A	N/A	Up to 20 cfs.	None	Provides access across North Canyon Channel for maintenance of Rocky Mountain Power infrastructure.
	Kim's Junction	Stop-log structure	Mini-Jordan Channel.	Based on water levels in Mini-Jordan Channel.	N/A	TBD	Add or remove logs depending upon desired water flow into Evaporative Basins MA.	Used to control water volume entering Evaporative Basins MA from Riverine MA.
	Flood Control Drain	Drainage ditch	Foxboro development east of LNP.	Very limited.	None	132 cfs.	None	Stormwater management drains for Foxboro development. Manager can lower gates, raise water surface in the pipes, and discharge stormwater to the LNP.
	Woods Cross Detention Basin	Drainage ditch and pond	Stormwater from developments to the east.	TBD	5 cfs; 3,288 acre-ft	TBD	None	Stormwater from Foxboro North will discharge to a channel along the west ROW line and convey water to the Woods Cross Detention Pond. During large storm events, the ditch will spill the western bank, and water will sheet flow into the LNP.
Wet Meadow	Artesian Wells 1 and 2	Artesian wells with gated pipes connected	Deep groundwater aquifer.	Year-round.	Groundwater rights, change applications pending.	TBD	Measure flow rates and water quality.	Two wells will be drilled in 2007 to supplement shallow groundwater support of wetland hydrology function.
	Artesian Wells 3, 4, and 5	Artesian wells with gated pipes connected	Deep groundwater aquifer.	Year-round.	Groundwater rights, change applications pending.	TBD	Measure flow rates and water quality.	Three wells will be drilled in 2007 to supplement shallow groundwater support of wetland hydrology function.
Farmington Bay	A-1 Canal	Canal	Runoff from Woods Cross and North Salt Lake.	TBD via flow measurement	None	Unknown	Estimate flow rates periodically.	Open canal across LNP that drains agricultural and urbanized lands east of LNP.
	Miscellaneous streams and drainages	Open channels	Other drainages in Centerville.	TBD via flow measurement	None	Unknown	Estimate flow rates periodically.	Several drainages run through the northern properties.
	Parrish Creek	Canal	Stormwater runoff from Centerville and Wasatch Mountains.	TBD via flow measurement	None	Unknown	Estimate flow rates periodically.	Open stream across LNP that drains mountain watershed and agricultural and urbanized lands east of LNP.
	Barnard Creek	Canal	Stormwater runoff from Centerville and Wasatch Mountains.	TBD via flow measurement	None	Unknown	Estimate flow rates periodically.	Open stream across LNP that drains mountain watershed and agricultural and urbanized lands east of LNP.

TBD = To be determined. N/A = Not applicable.

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Throughout the last 10,000 years, fluctuating volumes of runoff into Utah Lake have influenced the timing and amount of water and sediment in the Jordan River. Fluctuating GSL levels (see Figure 4) influenced the deposition of sediments where the Jordan River flowed into the lake forming complex delta. Over time, the flood flows across the delta developed a natural meander corridor and an associated floodplain while creating numerous oxbows, marshes, sloughs, and pothole ponds in the vicinity of the LNP. It is likely that, during most spring seasons, the river discharge exceeded channel capacity and flowed onto the adjacent floodplain (National Audubon Society 2000). The flow from the river likely fluctuated yearly with groundwater discharge and precipitation levels, and generally contained water year-round, even in drought.

Historical alteration of the Jordan River including channelization and levee construction have lead to a degradation of adjacent riparian habitat along the length of the river from Utah Lake to GSL. Development of the Salt Lake Valley during the last 150 years has included numerous irrigation projects and other channel alterations to maximize the water resources provided by the Jordan River. These irrigation projects diverted water from the river to agricultural lands throughout the valley, guaranteed water delivery during cyclical droughts, and created a buffer against flood flows. Flood control projects on the Jordan River have resulted in excavation of the channel and construction of levees along most of the Jordan River, from Utah Lake to GSL. The present-day channel and active floodplain of the Jordan River in most places is entrenched 6–10 feet below the historic floodplain (National Audubon Society 2000). Cumulatively, management and manipulation of the Utah Lake/Jordan River system for irrigation and flood control projects have significantly altered the natural flow regime of the Jordan River over time, reducing peak spring flows and altering historical riparian and aquatic habitats. As a result, many floodplain wetlands and water bodies have become disconnected from the Jordan River channel.

Within the LNP, a number of flow control structures have been installed along the Jordan River levee and other features may be installed in the future. The Jordan River will be used to supplement water from the North Canyon Channel for habitat restoration and enhancement within the MAs adjacent to the river (see Figure 3). Poor water quality, e.g., high nutrient levels that facilitate the establishment of common reed, limits this specific use of Jordan River water and also provides reason for restricting its application on the LNP.

Water levels in the Riverine MA are a function of inflow from the North Canyon Channel into the Mini-Jordan Channel and height of stop-log controls at the Jordan River outlet structure. The Jordan River and overflow from the Mini-Jordan Channel are also the major influences on water levels within the Evaporative Basins MA. Urban runoff and contribution of surface water via stormwater conveyance structures may also affect the levels of inundation and the timing and amount of water available for sustaining hydrology within these MAs.

### ***2.1.3 REGIONAL GROUNDWATER AQUIFER AND ARTESIAN WELLS***

A multi-layered, basin-fill, groundwater flow system exists within the region and includes two general types of aquifers along the southeastern shore of GSL. The two aquifers include a shallow, typically unconfined aquifer and a deeper, semi-confined principal aquifer. The shallow aquifer is generally the first saturated zone in the subsurface and is frequently present within the upper 50 feet of the basin-fill deposits, making it vulnerable to contamination from

anthropogenic sources. The shallow aquifer exhibits higher concentrations of dissolved solids, sodium and chloride than the deeper aquifer. The deeper aquifer, typically located more than 200 feet below the ground surface, is separated from the shallow aquifer by discontinuous clay layers deposited during previous climactic conditions. The confined aquifer is recharged through precipitation and snowmelt runoff from the Wasatch Mountains, which filters into the coarse deposits along the Wasatch Front. It is currently used for public supply and irrigation (Baskin et al. 2002). Low well yields and poorer-quality waters preclude use of water from the shallow aquifer (Baskin et al. 2002).

Aquifer formed wetlands occur where the shallow unconsolidated aquifers saturate surface soils, or where capillary action within soils and plant roots has drawn the water to the surface creating saturated conditions for all or parts of the growing season. This shallow aquifer is recharged by precipitation, upward leakage from the principal aquifer, and a very minor amount of river infiltration. Tail waters, irrigation water that has drained from a field, and percolation from flood irrigation have also contributed varying amounts of water to the shallow aquifer, but changes in land use and irrigation practices, where water is piped versus flooded, have reduced this input to nearly zero. According to Forster (2006), the deeper groundwater system historically recharged the shallow aquifer. Groundwater withdrawals and unmonitored artesian wells may have reduced artesian (upward) pressure from the deeper aquifer and may be influenced by future water use along the Wasatch Front. Changes in impervious surface and lack of shallow aquifer recharge have reduced hydrologic support of wetlands along GSL. During heavy precipitation events (especially in spring) infiltration of surface water may contribute a minimal amount of water to the shallow groundwater system, but poor drainage characteristics of the surface soils and evapotranspiration limit shallow aquifer recharge.

The level of the water table (i.e., the surface of the groundwater) in the shallow aquifer responds much more quickly to seasonal variation due to precipitation and evapotranspiration. The shallow aquifer water declines to its lowest levels in the summer/late fall and becomes highest in spring from winter deep aquifer recharge and mountain runoff infiltration (Forster 2006).

#### **2.1.4 FARMINGTON BAY WATERFOWL MANAGEMENT AREA (FBWMA)**

The FBWMA is located at the southwest corner of the lake and borders the LNP on the west side. Management of water levels is achieved by a series of diversion structures and weirs. The elevations of eastern ponds of the FBWMA have a significant impact upon the hydrology, water quality, and habitat of adjacent areas located within the Farmington Bay MA and cannot be controlled by the LNP Manager. Cooperation with FBWMA staff may be needed in the future to control invasive species and enhance adjacent habitats, but no management actions are proposed at this time.

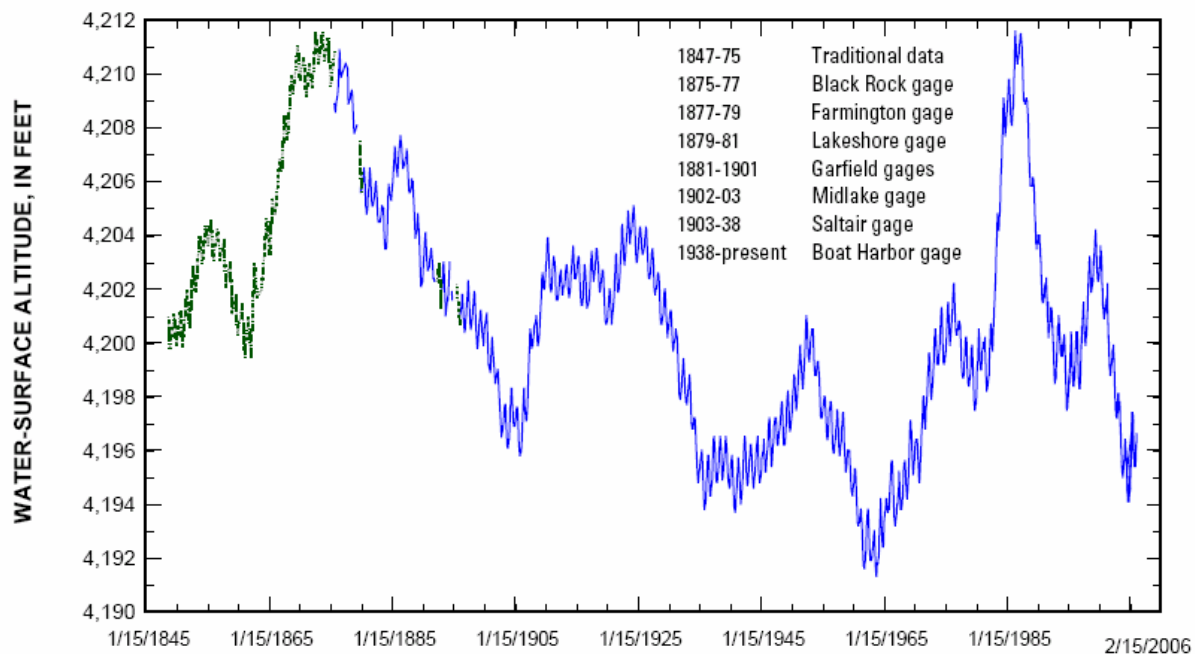
#### **2.1.5 GREAT SALT LAKE (GSL)**

The salinity of the GSL varies widely with fluctuations in the lake level and volume. The GSL's lowest recorded salinity was 10 % recorded in 1873 with the lake elevation at 4,211.7 feet and a total volume of 29.5 million acre-feet. The salinity reached a high of 27.5% salt by weight in 1963, when the lake elevation was at 4,191.6 feet and a total volume of 8.7 million acre-feet

(GSLBHO 2006). As a result of causeway construction the GSL is for all intents and purposes divided into three waterbodies of varying salinity. Consequently an analysis of salinity is more heuristic if a unit such as Farmington Bay is considered individually, rather than across the entire GSL.

The major surface water inflows into the GSL are the Bear, Weber/Ogden, and the Provo/Jordan River Watersheds. The rivers carry large quantities of dissolved salts into the lake which are left behind when the water evaporates. The salt concentrations vary with the amount of water flowing into the lake. During wet cycles the lake volume increases and the salt concentration is reduced. Conversely, during drought periods, the lake level recedes and the concentrations increase (Figure 5).

The yearly fluctuation of GSL levels has lead to development of lacustrine fringe wetlands within the areas below approximately 4,212 feet amsl, but control over the ecosystem processes that influence this type of wetlands is limited and is out of the scope of this plan.



**Figure 5. Yearly fluctuation of GSL measured at various locations, 1845–present (USGS 2002).**

## 2.2 WETLAND HYDROLOGY SUPPORT

For the wetlands within the LNP, hydrology is considered the basis for all wetland functions and the wetlands may carry out four general hydrologic functions (FHWA and USACE 2005a):

1. Storing surface water
2. Processing nutrients

3. Maintaining wetland hydrology
4. Dissipating energy in moving water

These processes may occur at a lower rate or not at all during winter, when vegetation growth is minimal.

Wetlands include areas that are periodically inundated or have soils saturated to the surface at some time during the growing season. While most of the wetlands in the LNP have been designated as groundwater slope or depressional wetlands, many of them lie within GSL's historic high-water elevation, and most are within the area of influence of maximal lake flooding (4,220 feet; FHWA and USACE 2005a).

In addition to natural cycles in precipitation and temperature, management practices can have a significant impact upon the amount of water that is available to support wetlands. Maintenance of wetland hydrology is also dependant upon the wetlands' ability to intercept and store groundwater and surface water. During extended periods of drought, the ability of the wetlands to maintain the wetland hydrology is reduced, and their ability to intercept groundwater or surface runoff becomes important. Several measures have been implemented within the LNP to restore wetland hydrology, including the removal of roads, drainage ditches, and drain tiles. These actions are intended to help raise the existing groundwater elevations and maintain wetland hydrology.

## **2.3 WATER QUALITY**

The restoration and maintenance of native habitats within the LNP will benefit water quality in the region through the establishment of proper functioning wetlands. All planned habitat types will improve water quality by removing both dissolved substances and suspended particulates through wetland biogeochemical processes. Dissolved substances will be removed from water through mechanisms such as absorption, adsorption, solubilization, oxidation, and biological transformation. Wetland vegetation removes pollutants, slows the velocity of water and reduces the water's ability to hold particles in suspension. Growing vegetation removes dissolved nutrients and compounds from the water and soil, often metabolizing them and sometimes sequestering them within plant tissues, although these pollutants may be re-released through plant decomposition.

Restoration activities identified in the HMP require water resources for the establishment and maintenance specified habitats. The water that is diverted and applied to the LNP must meet specific numerical and narrative water quality criteria. Utah law states that discharges to waters of the State provides must not impair the beneficial uses assigned to a waterbody. To meet Clean Water Act (CWA) goals, the State of Utah has implemented the Utah Water Quality Act and manages Utah Administrative Code R317, which has classified surface waters in Utah into beneficial use classifications (UDEQ 2006).

Water sources for the LNP are required to meet water quality standards for Class 3D waters. Class 3D waters are designated as waters that are protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, such as coldwater game fish,

warm water game fish and nongame fish respectively, and includes the necessary aquatic organisms present in their food chain. The numeric water quality standards for Class 3 waters are listed in Appendix C. Habitats developed and managed within the LNP area anticipated to improve water quality by natural processes occurring within the wetland environment.

Past water quality sampling by the Utah Divisions of Wildlife Resources and Water Quality has been used to establish baseline water quality conditions for the LNP. The contaminants of concern related to roadway runoff are oxygen demanding substances (BOD), solids, metals, chlorides, and nutrients because these contaminants may affect the aquatic habitat and organisms that support the food chain. The EPA's online water quality database, STORET, was queried for water quality pertaining to the area's water sources. Results for specific surface water quality parameters for all of the sampling in the vicinity of the LNP are listed in Appendix C. The STORET sampling sites are shown in Figure 2.

In May 1999, UDOT contracted with the Utah Division of Water Quality (UDWQ) to collect water samples from the North Canyon Watershed. The sampling established baseline water quality conditions findings for water available for habitat maintenance on the LNP. The data from water samples collected and analyzed for organic pollutants indicate that the water quality meets the appropriate standards for all inorganics in the North Canyon and Jordan River and organic pollutants in North Canyon. No data on organic pollutants was available for the Jordan River.

Analysis of the STORET data for the sampling time period indicate that the average results for the LNP's water sources do not exceed water quality standards, except the Biological Oxygen Demand (BOD) 5-day average of 5 mg/L, total dissolved solids (TDS), and total coliform. Elevated BOD levels can indicate a level of organic material within the water, which may cause the depletion of dissolved oxygen by aerobic decay of the organic material. Water quality concerns associated with the Jordan River include heavy algal blooms caused from excessive nutrients and high TDS loads. Water quality sampling indicates that regional water quality is below EPA standards.

## **2.4 WATER CONVEYANCE/INFRASTRUCTURE**

Water needed for habitat and wetlands will be supplied by multiple sources. Water availability and use will fluctuate throughout the year, depending on where the water is required and the time of the year in which it is needed. Water sources available to the LNP and their mechanisms of delivery are listed in Table 1 and depicted in Figure 3.

### **2.4.1 RIVERINE MANAGEMENT AREA (MA)**

The water sources and diversion structures within the Riverine MA are the primary tools available to the LNP Manager for the restoration and enhancement of habitats within the LNP. The main water source for both the Riverine and Evaporative Basins MAs is the North Canyon Watershed. Other water sources include the Jordan River and stormwater runoff from surrounding urban/rural areas. Water diversion/management structures within the Riverine MA include the North Canyon/Center Street Diversion, Jordan River Inlet, and the Jordan River

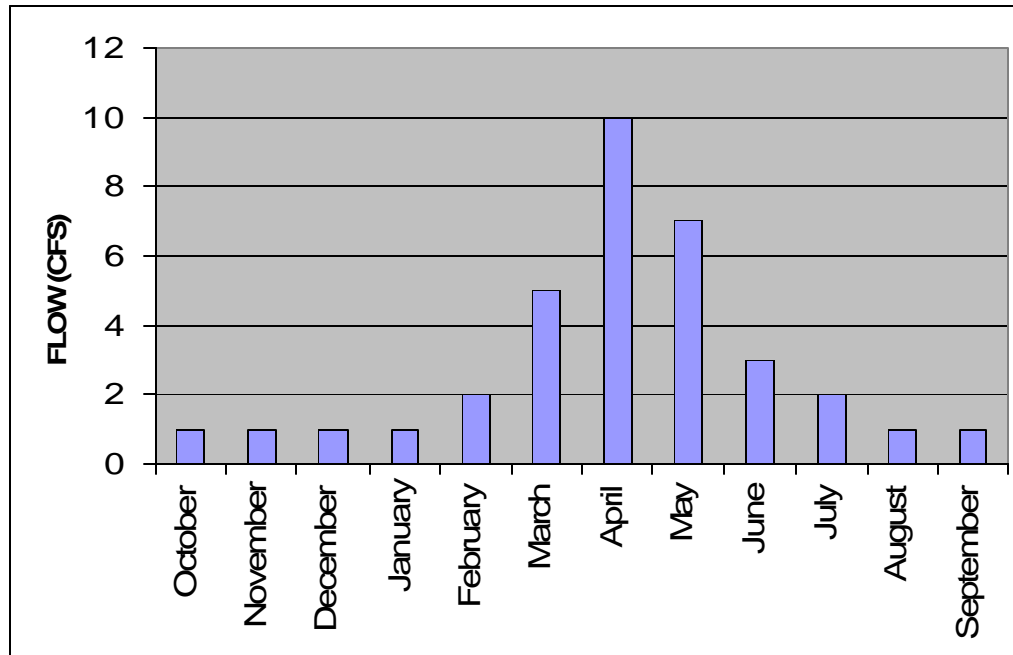
Outlet. These structures will be used to provide water to habitat features including the North Canyon Channel, Mini-Jordan Channel, and Sorensen's Slough. These features are discussed below.

### **2.4.1.1 NORTH CANYON WATERSHED AND CHANNEL**

The North Canyon Watershed provides water to the North Canyon Channel (Figure 6) and restores seasonal surface flooding of the historic Jordan River floodplain and will provide perennial flows in a relic Jordan River floodplain channel (Mini-Jordan Channel). The surface water flow into the Mini-Jordan Channel will attempt to mimic the seasonal flooding patterns of the floodplain and meander-belt located within the Riverine and Evaporative Basins MAs. Before channelization, levee construction and alteration of natural water regimes occurred, overbank flooding of the Jordan River supported the wetland hydrology in the floodplain, which contained side channels, oxbow lakes, and naturally diverse surface features. The hydrograph of North Canyon (Figure 7) is typical for mountainous areas along the Wasatch Front with peak flows in the spring months that taper off to a base flow of 1 to 2 cubic feet per second (cfs) in late summer and early fall months. UDOT has acquired the water rights to up to 20 cfs from this source (Holme 2006).



**Figure 6. Overview photograph of North Canyon Channel with portion of watershed in background.**



**Figure 7. General hydrograph of a typical watershed along the Wasatch Front (actual flow rates to be determined via field measurement).**

Water will be diverted into the North Canyon Channel at the Center Street Diversion, which is located along Center Street in Woods Cross, Utah (see Figure 3). Water is controlled at the Center Street diversion by a basic screw-gate, which can be controlled by the LNP Manager.

In order to accurately measure the flow of water through diversions, a number of devices have been constructed or instrumented to provide the means of measurement. In addition, these structures will be useful for water quality monitoring. Appendix A and Figure 3 contain detailed information on location and measurement of the points that will be used for water control and measurement.

#### **2.4.1.2 NORTH CANYON DIVERSION AT CENTER STREET**

A diversion structure was constructed along Center Street just west of Redwood Road to bring water into the LNP through a 30-inch pipe (Figure 8). The pipe discharges water within the Riverine MA. A screw gate opening along Center Street can be adjusted to control the flow of North Canyon water into the LNP. This structure is operated by turning a valve, which allows water to flow into the North Canyon Channel. Timing of adjustments will be determined through field measurement of flows at the Rocky Mountain Power culvert crossing, and will be adjusted based upon future determination of water quality and timing.



**Figure 8. Photograph of North Canyon/Center Street Diversion.**

#### **2.4.1.3 MINI-JORDAN CHANNEL**

The Mini-Jordan Channel (Figure 9) is one of the main open water/channel features within the Riverine MA. Water is provided to the Mini-Jordan at the pipe-crossing structure (see Figures 3 and 9), which can be adjusted to allow 0-100% of the water flowing through the North Canyon Channel into this feature.



**Figure 9. Overview photograph of Mini-Jordan Channel.**

#### **2.4.1.4 PIPE CROSSING STRUCTURE**

The pipe-crossing structure (Figure 10) will control the water flowing from the North Canyon Channel into the Mini-Jordan Channel. It can also be used to divert 0-100% of the Flood Control Drain water into the Mini-Jordan. This structure is basically a screw-gate structure that can be adjusted by turning large valves just east of the Mini-Jordan Channel. Stormwater can also be diverted to the Jordan River at this structure, to avoid allowing poor quality waters from entering the Mini-Jordan Channel.



**Figure 10. Photograph of pipe-crossing structure.**

#### **2.4.1.5 JORDAN RIVER OUTFALL**

The Jordan River Outfall provides one of the main water level controls within the Riverine MA. Adding or removing weir boards at the Jordan River Outfall controls the depth of water. The depth of water can range from a few inches to several feet. This provides the Manager the flexibility to set the water depth for a wide range of flow rates. To divert water from the Riverine MA the manager can add weir boards to raise the water surface to an elevation that will provide the head required to inundate the Evaporative Basins MA to the desired water depth. The shallow hydraulic gradient of the Mini-Jordan Channel will require that the LNP Manager know the condition of the outfall to obtain the appropriate stage-discharge curve for measuring inflows at the Utah power culvert that crosses the North Canyon Channel (see Appendix A). Figure 11 shows the outlet structure with all boards in place. Refer to Appendix A for flow measurement procedures for the control structures within the LNP.



**Figure 11. Photograph of the Jordan River Outfall.**

#### **2.4.1.6 JORDAN RIVER INLET**

A 24-inch culvert (Figure 12) was installed through the levee along the Jordan River at the southwest edge of the Riverine MA (see Figure 3). A screw-gate structure is used to control the water flow through the inlet and can be used to supplement North Canyon water for habitat restoration and enhancement within the Mini- Jordan Channel.



**Figure 12. Photograph of the Jordan River Inlet.**

#### **2.4.1.7 ROCKY MOUNTAIN POWER CULVERT**

A culvert (Figure 13) installed in the North Canyon Channel will be fitted with a staff gage at the inlet of the culvert to measure the depth of flow in the channel (stage). The Jordan River outlet weir-structure controls the depth of water in the Mini-Jordan and Sorensen's Slough habitat features, where the depth of water at the outlet can be measured at this point and the flow through the culvert can be obtained from charts for measuring inflow using methods outlined in Appendix A.



**Figure 13. Overview photograph of Rocky Mountain Power culvert.**

#### **2.4.1.8 SORENSEN'S SLOUGH**

After entering the Riverine MA, water meanders northwesterly through the Mini-Jordan Channel, which is directly connected to Sorensen's Slough (Figure 14), until exiting through water control structures either at the Jordan River or at Kim's Junction. The depth of the water within Sorensen's Slough is controlled at the Jordan River outlet, which is an adjustable weir (or stop log) structure to maximize management flexibility. The depth of water in the Mini-Jordan Channel can vary from about 6 inches to several feet by restricting flows through the Jordan River outlet, allowing water to fill up within the Sorensen's Slough. The optimal water depth during various times of the year will be determined through the adaptive management process.



**Figure 14. Overview photograph of Sorensen's Slough.**

## **2.4.2 EVAPORATIVE BASINS MA**

The main sources of water for habitat restoration and enhancement within the Evaporative Basins MA are the Mini-Jordan Channel at Kim's Junction, and the Jordan River at proposed future Jordan River Inlets.

### **2.4.2.1 FUTURE JORDAN RIVER INLETS**

Three structures are proposed along the Jordan River levee to divert water into specific closed evaporative basins. One 24-inch culvert (Mini-Jordan Inlet; see Figure 11) with a screw gate is in place along the Jordan River within the Riverine MA and three smaller, 18-inch-diameter culverts are planned along the Jordan River in the Evaporative Basins MA. Water is available from these diversions during times of high Jordan River flow rates when the water surface is above the flow line of the culvert. Flow rates are determined using culvert equations. Alternatively, for the Evaporative Basins MA, if these diversions are the only water source, the inflow can be determined by monitoring the water depth within the basins over time. A stage-storage (volume) relationship will be determined for the Evaporative Basins MA during the adaptive management period.

### **2.4.2.2 KIM'S JUNCTION**

This structure is similar to the Mini-Jordan Outlet, which is an adjustable weir or stop-log structure. Kim's Junction (Figure 15) will be used to allow water to pass from the Riverine MA to the Evaporative Basins MA. Water can be impounded within the Mini-Jordan, once the water surface reaches a predetermined elevation it will spill over the weir structure into the Evaporative

Basins MA. Adjusting the number of logs at this structure can control the amount and timing of water from the Riverine MA.

The amount of flow diverted at Kim's Junction can be estimated by subtracting outflow at the Jordan River outlet from inflow measured at the Rocky Mountain Power culvert or can be estimated by measuring the overflow on the stop-logs. Evapotranspiration losses may contribute to a margin of error when using this method.



**Figure 15. Photograph of Kim's Junction stop-log structure.**

### ***2.4.3 ALKALINE FLATS & SLOPE WETLANDS AND WET MEADOWS MAs***

The primary water sources for the Alkaline Flats & Slope Wetlands and Wet Meadows MAs will be proposed artesian wells and precipitation. Stormwater will also flow into the Alkaline Flats & Slope Wetlands MA through a ditch associated with the Woods Cross Detention Basin.

#### ***2.4.3.1 ARTESIAN WELLS***

Artesian wells will supply water to the created slope wetlands and wet meadows areas. A total of five wells will be drilled, with two being located in the Alkaline Flats & Slope Wetlands MA and three being drilled within the Wet Meadows MA (see Figure 3). In Figure 3, the purple dots adjacent to Legacy ROW show proposed locations for Wet Meadows MA artesian wells. The Alkaline Flats & Slope Wetlands wells are further subdivided as Slope Wetland 1 (south) and Slope Wetland 2 (north). Both wells need to supply water to 6-acre wetlands (12 acres total) with a maximum diversion rate of approximately 40 gpm or a diversion volume of approximately 35 acre-feet to maintain wetland function (HDR 2006). The other three wells located in the Wet Meadows MA will be used to reestablish hydrology within the MA, as the water that formerly

came from irrigation return flows up gradient of the MA and historically enabled the proper functioning of these wetlands has ceased.

The artesian wells will be fitted with a valve to control the flow rates. After surfacing from the artesian well, water will flow through a gated aluminum pipe, discharged diffusely, and allowed to flow over land. The proposed pipe is made of light-weight material and can be moved manually. Pipe lengths can be added or removed to get the desired spread width and overland flow coverage. Gated pipe with a 4- to 6-inch diameter and 30-inch gate spacing is proposed. The gates can also be adjusted to control the flow from each opening (Figure 16).

The gated pipe will extend laterally from the wellhead with two branches extending about 250 feet from a tee connection (about 500 feet of pipe for each well). The pipe will be set at a constant elevation. Considering the natural topography within the LNP is very flat (grades of 0% to 1.5%), the poorly drained soils, and the dense vegetation that is expected, overland flow should be maintained for a considerable length. About 500 feet of overland flow will be needed to obtain the required acreage. Appendix D includes the engineering design plans for the artesian wells, which shows the surface grades from points near the wellhead and running generally from east to west.

Hydrologic monitoring will include measuring the flow from the gated pipe and the aerial extent of irrigated lands. The wetted area will be delineated using a portable GPS unit. As mentioned, flow rates can be adjusted and lengths of gated pipe added, removed, or repositioned to irrigate the required acreage.



**Figure 16. Photo of typical gated pipe (Hastings Irrigation Pipe Co. 2006).**

### **2.4.3.2 FC DRAIN**

These are twin 48-inch pipes originating from the east side of the Legacy Parkway at the Foxboro development. These drains were installed to protect the Alkaline Flats & Slope Wetlands MA from uncontrolled stormwater discharges that could hurt the fragile nature of the area. The two 48-inch pipes terminate into a box culvert to cross under the North Canyon Channel. The box culvert is fitted with slide gates that can be lowered to block the flow of water in the storm drains. Water would then come to the surface and be discharged to the North Canyon Channel. No methods for recording flow from this source are available, but total flow can be determined by measuring discharge at the culvert.

### **2.4.4 FARMINGTON BAY MA**

#### **2.4.4.1 A-1 CANAL**

The A-1 Canal is the primary open water feature in the south end of the Farmington Bay MA. The canal provides water to private properties adjacent to the FBWMA. There are currently no plans to utilize water from the A-1 Canal for habitat enhancement purposes. If a future need is identified through monitoring, a stage discharge relationship could be established.

#### **2.4.4.2 PARRISH/BARNARD CREEK**

Parrish and Barnard Creeks flow across the middle portions of the Farmington Bay MA. Rocky Mountain Power will be installing culverts along these creeks, which could be used for future flow measurements. Both canals were recently dredged and allow water to flow into open water areas in the eastern ponds of FBWMA.

### **2.4.5 EXISTING STORMWATER MANAGEMENT**

Existing stormwater management features generally convey storm flows across the LNP and into the Jordan River to minimize runoff related water quality issues. The FC Drain conveys stormwater flows across the Alkaline Flats & Slope Wetlands MA into the Jordan River to protect the sensitive alkali flats habitat. Stormwater from areas south of 500 South in Woods Cross is channeled through ditches to a detention basin adjacent to Center Street. A ditch for Foxboro North will convey stormwater to a pond north of Foxboro. The culverts that will be installed across the Legacy Parkway are sized to allow up to 0.2 cfs/acre to flow under the road. Flows above 0.2 cfs/acre will be detained upstream from the Parkway (see Appendix D for stormwater control techniques).

## **2.5 WATER RIGHTS**

Acquisition of water rights was necessary for providing water to the MAs requiring irrigation for wetlands restoration and enhancement. Table 2 and Figure 17 identify water rights which are presently available for use on the LNP. Many of the land parcels obtained by UDOT for the Parkway and the LNP had appurtenant water rights and are use for management prescriptions.

**Table 2. Water Rights Available for Use on the LNP**

Water Right Name	Number	Source	Maximum Flow (cfs)	Actual Flow Volume (acre-feet)	Point of Diversion	Place (MA) of Use	Wildlife Use (maximum acre-feet available year-round)	Timing
Davis County Public Works Detention Basin	31-5217	Stormwater and snowmelt runoff.	20	TBD	Surface diversion in Woods Cross at Davis County Stormwater Detention Basin FC Drain; can block flow into Jordan River at screw gate.	Riverine and Evaporative Basins	10,080	Spring runoff and summer cloudbursts .
North Canyon Water	31-5210	Stormwater and snowmelt runoff.	20	TBD	Two headgates and ditches in Woods Cross controlled on LNP at North Canyon 30-inch pipe outlet into Mini-Jordan.	Riverine and Evaporative Basins	14,160	Spring runoff and summer cloudbursts .
Woods Cross Detention Basin	31-5213	Stormwater and snowmelt runoff.	5	TBD	Basin on LNP at approximately 2425 South Woods Cross.	Alkali	3,288	Spring runoff and summer cloudbursts .
Center Street Water	31-5206 (A7263)	Drains and Stormwater and snowmelt runoff.	6	TBD	Headgate at end of ditch into Mini-Jordan; used to supplement 59-5712 and 59-5780.	Riverine and Evaporative Basins	1,400 approved only for irrigation and wetland mitigation from April 1 to October 31 each year	Spring runoff and summer cloudbursts .
Faye Jensen Water	59-5712 (A29548)	Jordan River	Flow dependant on reaching maximum at diversion allowed	48	Mini-Jordan Inlet from Jordan River; used to supplement 31-5206 and 59-5712.	Riverine and Evaporative Basins	9.45	May be used anytime when surplus to downstream users' diversions
North Point Consolidated Irrigation Company Water	59-5780 (D1463) (A29547)	Jordan River.	Flow dependant on reaching maximum at diversion allowed	60	Mini-Jordan Inlet from Jordan River; used with 31-5206 and 59-5712.	Alkali	48	May be used anytime when surplus to downstream users' diversions

TBD = To be determined.

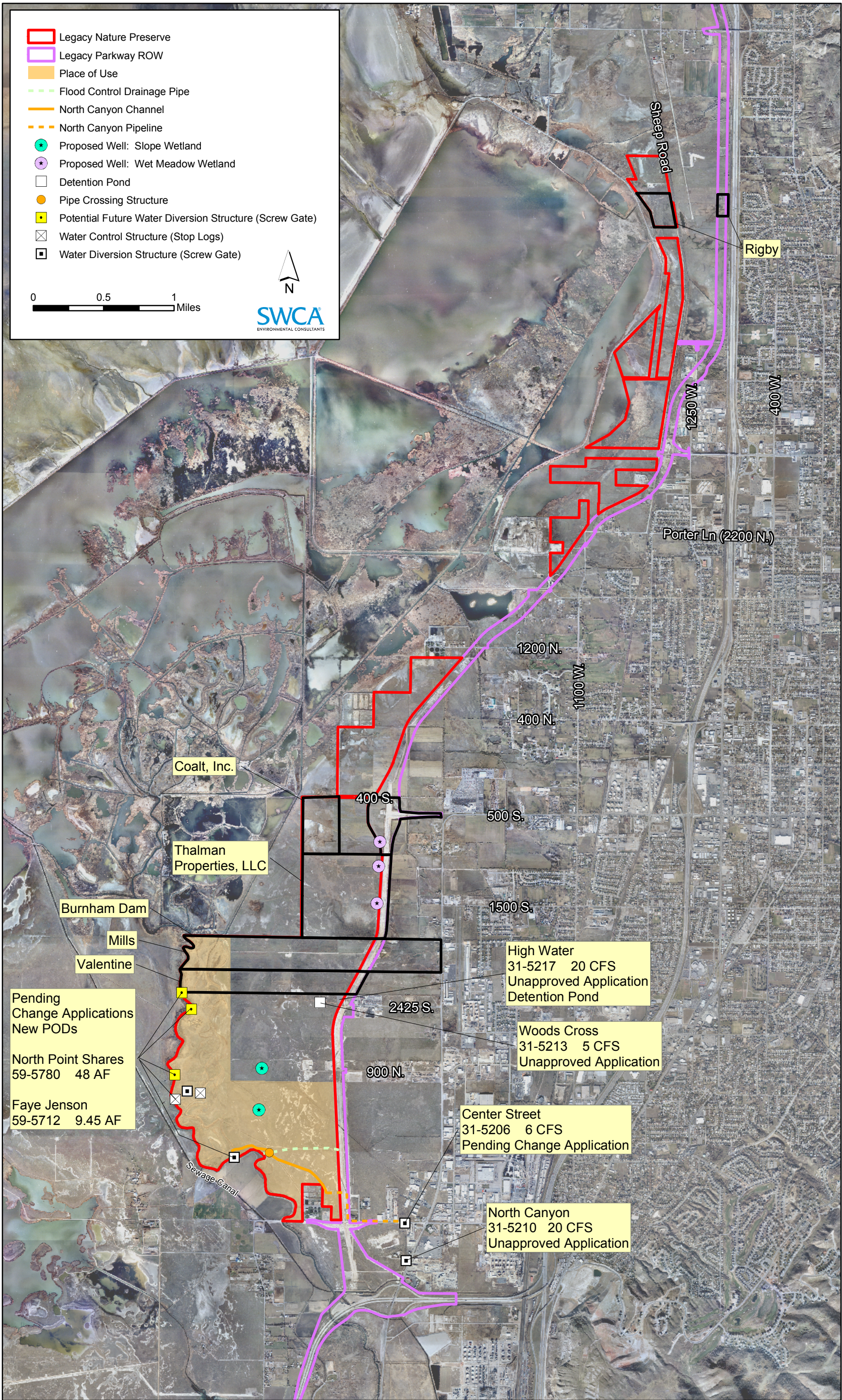


Figure 17. Water rights presently available for use on the LNP.

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Others are of limited value because of flaws in the land title, questions about the history of water use, or because only a very small quantity of water is involved. In these instances, the cost of acquiring and updating the title on the water rights exceeds their expected value. Sufficient water rights have been acquired for the diversion and use of groundwater from the deep aquifer wells located within the wet meadow and slope wetland MAs.

A detailed water accounting and record keeping method will be developed to document beneficial use of individual water rights. The CWMP provides a starting point for this record which will records of water usage, point of diversion, place of use, date of application as well as major source of water supply and any significant supplemental sources that were available. Additional water rights may be acquired in the future.

The evaluation of the existing water rights on LNP lands has been completed in a three-step process:

1. identifying all water rights possibly appurtenant to the parcels;
2. analyzing the water rights for title, use, and potential problems and identifying the amount of useable water that could be acquired for each parcel; and
3. assessing required administrative actions such as updating titles and acquiring change applications to use the water for LNP purposes.

The following points of diversion are presently available for use within the LNP for the application and maintenance of habitats that have been established:

- Davis County Public Works Detention Basin
  - Surface diversion in Woods Cross at Davis County.
  - Stormwater detention basin FC Drain.
  - Dates available for irrigation: April 1 to October 30.
  - Can block flow into Jordan River at screw gate.
- North Canyon Water
  - Two headgates and ditches in Woods Cross.
  - Controlled on LNP at North Canyon 30-inch pipe outlet into Mini-Jordan.
  - Available for wildlife use year-round.
- Woods Cross Detention Basin
  - Basin on LNP.
  - Dates available for irrigation: April 1 to October 31.
- Center Street Water
  - Headgate at end of ditch into Mini-Jordan.
  - Use as supplement with water rights 59-5712 and 59-5780.
  - Available for wildlife use year-round.
  - Faye Jensen Water

- Mini-Jordan Inlet from Jordan River.
  - Use with water rights 31-5206 and 59-5780.
  - Dates available for irrigation: April 1 to October 31.
- North Point Consolidated Irrigation Company Water
  - Mini-Jordan Inlet from Jordan River.
  - Use with water rights 31-5206 and 59-5712.
  - Dates available for irrigation: April 1 to October 31.
- Mills and Valentine-Merrell Water
  - Water rights associated with the groundwater wells.
  - Available for wildlife use year-round.

## **3.0 GENERAL WATER MANAGEMENT**

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The general management actions discussed in this section are intended to provide a set of "tools" that the Manager will be able to use to enhance or maintain water quality and habitat functionality within the LNP. The habitat goals outlined in the HMP will be maintained through the proper use and management of water. Flow augmentation and manipulation will be used to provide the basis for a dynamic, naturally functioning ecosystem. Through use of the following management actions, the Manager will test and refine the water management system to obtain the maximum achievable habitat quality and function for desirable flora and fauna.

The following sections detail the specific tools available for the Manager to control timing, duration, depth and seasonality of water use on the LNP. Specific use of these tools within each MA is discussed in Chapter 4 of this document. Monitoring protocols and evaluation of success criteria are discussed in Chapter 5 and will be used to systematically test assumptions in order to adapt and learn. General guidance about the process of adaptive management used to develop these tools can be found in the AMP.

The major management actions that will be under control of the Manager will include adjustment of flow rates into and out of the Riverine and Evaporative Basins MAs and adjustment of flows from artesian wells. A number of water control structures have been installed during the past few years that will facilitate these actions. Use of existing water control structures and monitoring of results of differing flows through these structures will determine how adaptive management will be used to change flow rates, install more structures, or modify existing structures. The adjustment of flows and addition or change in location of gated pipe connected to artesian wells will be the major management actions influencing the hydrology of proposed slope wetlands. The general management actions that can be taken by the Manager are outlined in the following sections.

### **3.1 WATER IMPOUNDMENT**

Water impoundment will be the primary means of controlling water depth to provide maximum benefit for the highest number of priority bird species and their associated species guilds. Impoundment will also allow water to evaporate and leave salts in surface soils in locations where increased soil salinity is desired. This process of salt accumulation may be supplemented with direct application of salts in the future.

Water impoundment will be used to create or enhance functionality of the salt-affected floodplain, freshwater marsh, and riparian habitat types. The priority bird species that will benefit from water impoundment for foraging, resting, or nesting include American Avocet, Cinnamon Teal, Black-necked Stilt, Forster's Tern, Wilson's Phalarope, Bald Eagle, and White-faced Ibis. The needs of all priority species cannot be met concurrently, due to different requirements on timing and depth of inundation, so management of impoundments will attempt to support the hydrology required to increase and maintain species richness and diversity to benefit the greatest number of species. Adaptive management of water impoundment details will occur based upon results from monitoring and evaluation of habitat functionality.

Water will be impounded by means of controlling inflow and outflow from areas within the Riverine and Evaporative Basins MAs and is discussed in detail in Chapter 4. Priority species that require shallow water and mudflats will benefit from periodic flooding and drying of shallow basins in the salt-affected floodplain habitat.

### **3.2 WATER STORAGE AND RETENTION**

Water storage and retention are important features of floodplain wetlands and depressional areas within the Riverine and Evaporative Basins MAs. Floodplains naturally attenuate flood flows by storing water during high runoff events. This function of the floodplains along much of the Jordan River from Utah Lake to GSL has been compromised due to previous channelization and dredging of the river. Natural flow regimes and the processes related to yearly seasonal flooding have also been compromised due to construction of levees and the Surplus Canal. The floodplain area within the LNP has provided water storage during periods of high runoff and will also provide some storage if and when GSL rises in the future. Although the extent and magnitude of future rises in water level for GSL are unknown, they are discussed as a potential uncontrolled aspect of LNP management.

A small amount of water storage will also occur in shallow depressional areas present in the Alkaline Flats & Slope Wetlands MA. The majority of water stored in these areas will be during times of spring runoff and during precipitation events. This water storage will attenuate flooding and runoff from the area during periods of high-intensity precipitation.

### **3.3 WATER FLOW-THROUGH**

Water flow-through can be divided into two general types, surface water and groundwater flow-through. Surface water flow-through will play an important role in the Riverine MA and will also occur down-slope from the artesian wells in the Alkaline Flats & Slope Wetlands MA and the Wet Meadows MA. Groundwater flow-through will be the dominant hydrologic process occurring within the areas influenced by the artesian wells. Generally, groundwater flow-through will be an important aspect of creating of slope wetlands under the USACE mitigation requirements.

Slope wetlands are one of the most difficult types of wetlands to create due to the numerous factors involved in saturating surface soils for certain periods of the year. The amount of water that will flow through the surface soils is based upon soil factors including available water capacity (AWC), organic materials present, soil drainage class, soil structure, salinity, rock fragments, and most importantly saturated hydraulic conductivity (Ksat). Each MA has slightly different soil characteristics, an understanding of which is important to the successful implementation of management practices. Other factors that influence water flow-through are plant root structure, biological activity, and human disturbance of soils.

### **3.4 INUNDATION**

Flooding of the Jordan River floodplain would result in inundation of sections of the Riverine and Evaporative MAs. As indicated in the HMP, inundation could be used to control invasive species, such as phragmites. Inundation could also be used to provide wildlife habitat components needed for resting, nesting or foraging of specific priority species. (Refer to the HMP, Table 3.4, for a comparison of inundation levels related to priority bird species.)

The priority species that would benefit directly from inundation include Bald Eagle, Forster's Tern, Wilson's Phalarope, Cinnamon Teal, Black-necked Stilt, American Avocet, and White-faced Ibis. The maximum inundation depth for these priority species would be 6–12 inches (15–30 cm). Shallow depths of 0–6 inches (0–15 cm) would be a lower priority. A small area of deeper (12–24 inches, or 30–60 cm), non-flowing water would occur in the northern area of the Evaporative Basins MA against the new State Canal berm and would be especially beneficial to White-faced Ibis.

### **3.5 DIVERSIONS**

Diversions will be used to supply water to certain areas of the Riverine and Evaporative Basins MAs. The diversion structures presently in use at LNP are screw-gate diversions and stop-log control structures. The two screw-gate structures include the Mini-Jordan Inlet and North Canyon Diversion (see Figure 11). Stop-log control structures are present at the Kim's Junction (the inlet to the old meander channel) and at the Jordan River outlet. Details of Jordan River diversion structures can be seen on UDOT Roadway Design detail sheet DT-03. The use of specific diversion structures is discussed in Section 3.5.

Primary sources of water for diversion into these areas include the North Canyon conveyance feature and the Mini-Jordan Inlet along the Jordan River. A flow of up to 20 cfs will be available from North Canyon and a volume of approximately 60 acre-feet annually will be available from the Jordan River inlet. Future inlets along the Jordan River will also be installed and will provide additional of volume. These water needs are subject to watershed processes including precipitation and spring runoff. Diversions will also be used to maintain minimum flows in channels during the low-water seasons.

### **3.6 IRRIGATION**

The use of irrigation will be the primary means of water dispersal related to the artesian wells in the Wet Meadows MA and Alkaline Flats & Slope Wetlands MA. The types of irrigation techniques were discussed in Section 3.6 of this document. Water flow rates will be measured by use of a standard bucket-fill method. Irrigation areas will be adjusted due to observed field conditions of inundation and saturation in surface soils.

### 3.7 STORMWATER MANAGEMENT

Although the goals of the LNP are not to treat or control stormwater discharges, the LNP itself will likely treat and/or remove some of the contaminants from water running off local impervious surfaces that cannot be treated by traditional stormwater management techniques. During times of high precipitation rates, stormwater flows may be diverted to the Jordan River to minimize pollutant runoff onto the LNP. UDOT will install appropriate stormwater management features on the Legacy Parkway to treat road runoff and potential spills. Although most suspended sediment will be removed from surface waters through treatment before it enters the LNP, most suspended sediments in stormwater will settle out through the simple mechanics of overland flow. Developing areas adjacent to the LNP will be required to pre-treat stormwater before it enters the LNP. Future stormwater management actions include adding oil/water separators, creating additional settling basins, and creating nutrient treatment ponds or wetlands within the existing conveyances.

The LNP is located in a highly urbanized region with tremendous growth and development occurring near the boundaries of the LNP. Stormwater discharge occurs through multiple sites and from multiple sources. The volume, peak flows, and quality of the discharge waters into the LNP are dependant upon the level of development within the adjacent municipalities, the level of contamination of runoff waters and the severity of the actual storm event. Table 3 summarizes the stormwater conveyances that discharge into the LNP and the estimated peak flow rates. The location of each outlet that eventually is discharged onto the LNP at the boundary is shown in Figure 2.

**Table 3. Municipalities that Discharge Stormwater to the LNP**

Municipality	Conveyance Name	Peak 100-year Storm Flow (cfs)
Centerville	Ricks Creek	450
	Barnard Creek	200
	Parrish Creek	350
	Deuel Creek	350
Bountiful	Stone Creek	500
	Barton Creek	450
	Mill Creek	1,000
	A-1	200
	A-2	30
North Salt Lake City	North Canyon*	210

\* North Canyon stormwater source is North Salt Lake stormwater detention pond, which stores waters from North Canyon Creek, Hooper Draw and stormwater runoff from North Salt Lake.

The manager should be involved with regional planning efforts as the LNP is a major downstream water user. Furthermore, the manager should encourage that local municipalities mandate the use of BMPs for stormwater quality maintenance and treatment for new

developments. The primary purpose of using stormwater BMPs is to protect the existing preferential habitat management activities of the LNP and protect receiving waterbodies located in the region by the reduction of pollutant loads and the reduction of discharges (volumetric flow rates) onto the LNP (ECY-DOE 2005). The manager should also be cognitive of possible illicit discharges directly onto the LNP without pretreatment, which could harm wetland aquatic function and reduce wetland production (see Appendix D for stormwater BMPs).

Nearby communities need to invest in the administration of watershed management plans in order to protect the unique resources of the LNP. One of the goals of LNP stewardship is to increase public awareness and understanding of the watershed and the LNP itself. Programs that may lead to greater public activity and knowledge in a watershed include watershed advocacy, watershed education, pollution prevention, watershed maintenance, monitoring, and restoration. Additional guidance on stormwater management for the LNP can be found in Appendix D.

The EPA's Phase I stormwater regulations governs stormwater pollution from construction sites greater than 5 acres in size. With the implementation of the Phase II stormwater regulations, the area threshold has been reduced to 1 acre in size. The requirements of this provision apply regardless of the type or sequencing of construction.

Current federal and state regulations require controls to be implemented to prevent stormwater discharges from construction sites from adversely impacting water quality. Utah rules and regulations prohibit discharges from construction sites that would cause or contribute to a violation of water quality standards or that would fail to protect and maintain existing designated uses. These regulations also require all control measures to be adequately maintained to effectively reduce or prohibit erosion. Erosion and sediment controls must be designed to retain sediment on-site to the extent practicable with consideration for local topography, soil type and rainfall.

### **3.8 WATER RIGHTS ENFORCEMENT**

The enforcement of water rights is important to provide a legal means for LNP managers to justify that water rights are being used on the LNP for beneficial uses. The main concerns with water rights for the LNP Manager will be monitoring, recording, and reporting uses and documenting all diversions and impoundments of water on the LNP. Monitoring will provide data and evaluation of annual records will help determine if water is being diverted from LNP. Accurate record keeping is prudent to prove beneficial use of water rights owned.

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## 4.0 MANAGEMENT ACTIONS TO BE IMPLEMENTED, BY MA

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The management and input of the water resources within the LNP will be vital to the overall success of the restoration and ecological function of the individual MAs. Each of the MAs has unique hydrologic and biotic requisites necessary to support the physical and biological properties of the habitats. Determining the correct amount of water applications is thus vital to restoring, enhancing, and maintaining wetland function. A preliminary water budget for each MA was developed to determine actual water requirements needed to fulfill the habitat support and production goals (see Appendix B). The water budget analysis is a method to predict the monthly water requirements of wetlands, based on a balance of estimated inflows (direct precipitation, surface inflow, and subsurface inflow) and outflows (surface outflows, subsurface outflows, and evapotranspiration). More comprehensive information will be needed to refine the budget. Some of the additional information is available from local, state, or federal natural resource agencies or GIS data suppliers. A typical water budget uses the following data as inputs:

- Direct precipitation
- Surface inflows, such as stormwater or irrigation
- Subsurface inflows, such as groundwater
- Surface outflows, such as runoff
- Subsurface outflow, such as infiltration
- Evapotranspiration, including plant uptake.

Each of these variables will be included in the water budget equation:

$$P + SWI + GWI - ET - SWO - GWO = \Delta V$$

Where P = precipitation, SWI = surface water inflow, GWI = groundwater inflow, ET = evapotranspiration, SWO = surface water outflow, GWO = groundwater outflow, and  $\Delta V$  = change in storage.

These values are measured directly (or indirectly through subtraction) or obtained from readily available sources. Seasonal variation may limit the accuracy of inputs related to temperature and precipitation.

The change in storage calculated above is the amount of water that is necessary to support the wetlands and provide the inundation required in some MAs for habitat support. To assist in the adaptive management strategy requirements and produce water quality requirements, Table 4, below, lists each of the MAs, the physical parameters and habitat goals established, and the anticipated resources necessary to maintain the habitat.

**Table 4. Habitat Goals and Related Water Depths, by MA**

MA	Total Acres	Water Sources <sup>1</sup>	Habitat Type <sup>2</sup>	Habitat Sub-class <sup>2</sup>	Water Depth (inches)	Water Duration
Riverine	187.0	North Canyon, Hooper Draw, Jordan River, groundwater, precipitation.	Freshwater marsh	Deepwater	12+	Year-round
				Emergent marsh	2-24	Seasonal
				Wet meadow	2+	Spring and/or summer
Evaporative Basins	221.5	Jordan River inlets, North Canyon, precipitation.	Riparian	Streambank	Alternating depths	Year-round
				Overbank	Sheet flows	Flood flows
			Freshwater marsh	Deepwater	12+	Year-round
				Emergent marsh	2-24	Seasonal
			Riparian	Wet meadow	2+	Spring and/or summer
				Streambank	Alternating depths	Year-round
				Overbank	Sheet flows	Flood flows
Wet Meadow	273.7	Artesian wells, precipitation.	Salt-affected floodplain	Salt meadow	Inundated in spring	Seasonal inundation
				Evaporative basin	Dynamic shoreline for maximum production of macroinvertebrates.	Seasonal inundation
			Alkaline knoll	Upland	None	Seasonal
				Alkaline flats	Inundation	Seasonal
				Salt meadow	Inundated in spring	Seasonal inundation
			Freshwater marsh	Deepwater	12+	Year-round
				Emergent marsh	2-24	Seasonal
Alkaline Flats & Slope Wetlands	852.3	Artesian wells, precipitation.	Alkaline knoll	Wet meadow	2+	Spring and/or summer
				Upland	None	Seasonal
				Alkaline flats	Inundation	Seasonal
				Salt meadow	Inundated in spring	Seasonal inundation

Table 4. Habitat Goals and Related Water Depths, by MA

MA	Total Acres	Water Sources <sup>1</sup>	Habitat Type <sup>2</sup>	Habitat Sub-class <sup>2</sup>	Water Depth (inches)	Water Duration
			Grassland	Short-grass prairie	Saturation	Growing season
			Freshwater marsh	Tall-grass prairie	Saturation	Growing season
				Deepwater	12+	Year-round
				Emergent marsh	2-24	Seasonal
				Wet meadow	2+	Spring and/or summer
Farmington Bay	569.4	Surface water, stormwater, precipitation.	Salt-affected floodplain	Salt meadow	0-6	Seasonal inundation
				Evaporative basin	0-12	Seasonal inundation
			Alkaline knoll	Upland	None	Seasonal
				Alkaline flats	Inundation	Seasonal
				Salt meadow	0-6	Seasonal
			Freshwater marsh	Deepwater	12+	Year-round
				Emergent marsh	2-24	Seasonal
				Wet meadow	2+	Spring and/or summer

1. Source: LNP Adaptive Management Plan.

2. Source: LNP Habitat Management Plan.

## **4.1 HABITAT TYPES**

All of the MAs will require different levels of management related to the operation of conveyance features and maintenance of ecosystem function. The adaptive management practices that have been established for the sites will provide the means to evaluate and adjust practices that have been implemented within each MA based upon the current habitat conditions. The Manager will have maximum flexibility to change management actions based upon observed trends and results of monitoring as long as those changes are intended to meet the requirements of the USACE permit and the goals of the HMP. The Collaborative Design Team (CDT) and the Scientific Advisory Committee (SAC) will provide advice and guidance for the Manager and will review the reasoning for changes in management.

Land types include uplands and grasslands, wetlands and marshes, floodplains, and open waters. Functionality of wetlands includes wetland hydrology, biogeochemistry, particulate retention, habitat structure, and habitat connectivity (FHWA and USACE 2005a) and varies by type. The occurrence and distribution of wetlands in the LNP has been affected by anthropogenic activity and existing wetlands have been degraded so that the capacity to perform natural functions, including wildlife support varies greatly. The majority of wetlands found in agricultural areas have been grazed and/or cultivated. The more intensely these wetlands have been subjected to agricultural activities, the lower the functioning capacity. (FHWA and USACE 2005c). The hydrologic functions for existing wetland habitat classes and the wetland subclasses present within the LNP are described below.

Within the LNP, three wetland classes (depressional, slope, lacustrine fringe) and seven wetland cover types (forested wetland, shrub-scrub, emergent marsh, wet meadow, playa, unconsolidated shore, and open water) exist (FHWA and USACE 2005c). Wetlands occurring in topographic depressions allow accumulation of surface water. Dominant water sources are precipitation, groundwater discharge, and interflow from adjacent uplands.

### **4.1.1 DEPRESSIONAL WETLANDS**

Depressional wetlands capture and detain precipitation sheet flow, thereby decreasing the amount and velocity of stormwater runoff, reducing peak floods and distributing storm flows over longer periods. These basins provide habitat for aquatic organisms and help maintain the physical and biogeochemical processes. Water stored in wetland basins percolates slowly into the soil or into the groundwater, which can sustain a high water table and support adjacent wetlands.

### **4.1.2 SLOPE WETLANDS**

Slope wetlands normally are found where there is a discharge of groundwater to the land surface and always have a slope with elevation gradients ranging from steep hillsides to slight slopes. Principal water sources are usually horizontal and vertical groundwater flow and precipitation runoff from surrounding uplands. Lacustrine fringe wetlands are located adjacent to lakes where

water elevation of the lake maintains the water table in the wetland (Smith et al. 1995). The hydrology in these wetlands will be supported through artesian well irrigation.

Two artesian wells will be drilled within the Alkaline Flats & Slope Wetlands MA to supply water to the created wetlands. The mitigation requirements under the 404 permit involve the creation of twelve acres of groundwater slope wetlands on the boundary between the Riverine and the Alkaline Flats & Slope Wetlands MAs. The water budget analysis predicted the monthly water requirements to create 12 acres of wetlands. A minimum discharge rate of 0.05 cubic feet per second (cfs) (24 gallons per minute [gpm]) during the month of March and a maximum discharge rate of 0.09 cfs (40.4 gpm) during the month of July is anticipated in order to balance annual consumptive use for the twelve acres of created slope wetlands. The annual volume of water required for the wetland is estimated to be 70 acre-feet.

The source of the flowing artesian groundwater is referred to as the East Shore aquifer system. Reportedly, the groundwater that supports the wetlands in the study area is derived primarily from upward vertical flow from the deep (200+ feet) aquifers (Forster 2006). The historical water source for the Corps' reference wetland was artificially supplied through irrigation diversions from historic artesian wells and surface waters. This suggests that the water quality of the groundwater supply from artesian wells drilled into a deeper water-bearing zone is likely to be suitable for the desired wetland species. The water quality of the deeper aquifer varies with depth and location, but it is generally characterized as having lower concentrations of dissolved solids than the shallow aquifer (i.e., generally less than 500 mg/L; Baskin et al. 2002).

#### **4.1.3 LACUSTRINE FRINGE WETLANDS**

Elevation and depth of lacustrine fringe wetlands varies directly with the rise and fall of the water level in GSL. Because they are part of a larger lacustrine system, they primarily provide long-term open-water habitat. When lake levels are low, lacustrine fringe wetlands can be shallow water systems. When the lake levels are high, such as they were in the mid 1980s, the lacustrine floodplain is submerged and changes to open water. During low lake levels much of the adjoining floodplain is dry during all or a portion of the year. Alternating wet and dry periods within the floodplain are critical components for maintaining productivity of this system.

#### **4.1.4 FORESTED AND SCRUB-SHRUB WETLANDS**

Forested and scrub-shrub wetlands are limited on the LNP and generally occur along the banks of the Jordan River and in small areas adjacent to canals. These types of wetlands will be significantly improved through proposed habitat restoration plans.

#### **4.1.5 EMERGENT MARSH**

For emergent marsh wetlands the hydrologic source is provided by groundwater and/or surface water. Water covers the ground surface for long periods of time during the growing season with depths ranging from about 2 inches to up to 2 feet, but the depth is not so great that it restricts growth of emergent plant species. Areas where emergent marsh is supported primarily by groundwater are typically located in depressions where the ground surface drops below the level

of the water table. During the spring and early summer months, when the water table is high due to snowmelt and precipitation, these areas are inundated. As the level of the water table drops in the summer months, the marsh areas may no longer be inundated, although the soils remain saturated.

#### **4.1.6 WET MEADOW**

A wet meadow is a wetland plant community characterized by grasses and other low-growing, perennial monocots and forbs. Although the soil may be saturated for long durations, the vegetation is generally not of the emergent type. The hydrology of the wet meadow cover type is provided flood irrigation from surrounding agricultural land and groundwater from the shallow sub-surface aquifer. Early in the growing season the level of the water table may be higher than the ground surface, causing inundation. However, this inundation occurs less frequently and for a shorter duration than in marsh. The bottom of the wetland depression may not come in contact with groundwater except during periods of high water table elevations. Because of this difference, wet meadows may be inundated only for brief periods, although the soils may be saturated at the surface for extended periods. As the water table drops in the summer months, the wet meadows become drier, and upland species may begin to grow by late summer.

#### **4.1.7 PLAYA AND DEPRESSIONAL WETLANDS**

Vegetation in the playa cover type is usually sparse, typically between 5% and 30% aerial cover. The vegetation is not uniformly distributed across the playas but tends to be concentrated around the margins. The hydrology of playas in the study area is provided primarily by surface water. Playas are typically located in the lowest topographic positions of areas with internal drainage. They collect much of the runoff from adjacent areas following spring precipitation events, and because of the high clay content of the soils, the water will pond. Most of the standing water in playas exits through evaporation, which can draw minerals from surface soils and deposit salts from on the surface.

#### **4.1.8 UNCONSOLIDATED SHORE AND OPEN WATER**

Unconsolidated shore and open water are primarily present along the northern half of the LNP. These wetlands occur on the edges of FBWMA and will not be actively managed.

### **4.2 RIVERINE MA**

The primary tools available for management of the Riverine MA include diversion, inundation, flow-through and impoundment.

The habitat types present within the Riverine MA include salt-effected floodplain, freshwater marsh, and riparian habitats. Impoundment will enhance foraging habitat for some priority species, and will also provide protection for nesting areas of other priority species. The primary means of controlling flooding depth and duration within the Riverine MAs is presently flow in the North Canyon conveyance feature, Jordan River flow and the Mini-Jordan Outlet. Flooding from the Jordan River does not presently occur on a natural cycle due to upstream diversions and

irrigation practices within the Salt Lake Valley and a system of levees and dredge piles at the LNP. A minor amount of water storage would occur within the low-lying areas of the Riverine MA.

Water flow-through will be an important tool for maintaining habitat and function of Sorensen's Slough and the Mini-Jordan features of the Riverine MA. Water that is diverted through the Mini-Jordan Inlet and from the North Canyon Diversion will be the primary water supply for these habitat features. Due to the very poorly drained soils with very low hydraulic conductivities (0.9  $\mu\text{m}$  per second) within the Riverine MA, groundwater recharge is unlikely to occur within this area. The depth of water can be controlled at the outlet and is not necessarily a function of the flow rate.

The timing of surface water flow-through should coincide with natural cycles of spring runoff and summer precipitation. The amount of water needed to mimic a naturally functioning side-channel of the Jordan River will vary seasonally. Flowing water in these habitat features will provide shallow to deep water within Sorensen's Slough, thereby providing some protection for potential nesting Forster's Tern or White-faced Ibis on Lord Byron's Island. To mimic the natural functioning of the side channels of the Jordan River floodplain, water should be present in Sorensen's Slough year-round. Perennial flows will provide feeding areas and would be beneficial to many priority species.

Specific water delivery from the Jordan River at the Mini-Jordan Inlet may need to be adjusted if large stormwater flows from the North Canyon drainage basin are expected. Inflows will be measured at the Rocky Mountain Power culvert crossing, as detailed in Appendix A, to allow the Manager to determine supplemental flows required from the Mini-Jordan Inlet. Special care will need to be taken not to disturb feeding or nesting Bald Eagles if adjustments to water control structures are needed during the seasonal buffer for the Bald Eagle nest. An agreement has been reached with the USFWS regarding access to water control features.

### **4.3 EVAPORATIVE BASINS MA**

The primary tools available for management of the Evaporative Basins MA include diversion, inundation, and impoundment. The freshwater marsh habitat type may also benefit indirectly from artificially raised shallow groundwater levels due to irrigation from artesian wells.

Water from the Mini-Jordan Inlet will flow through the Mini-Jordan Channel and into the Evaporative Basins MA through a stop-log structure (Kim's Junction) at the south end of an old meander channel that exists in the Evaporative Basins MA. Adjusting the number of logs at this structure can control the amount and timing of water from this source. A stop-log structure (Jordan River outlet) is also present at the end of the Mini-Jordan and is used to impound water and provide flow into the Evaporative Basins MA. A slide-gate structure is also present along the Mini-Jordan and can be adjusted to allow the desired flow to enter this MA.

The habitat types present within the Evaporative Basins MA include riparian, salt-affected floodplain, and freshwater marsh. The priority bird species that will benefit from various management of water levels and surface water flow-through include Bald Eagles, Black-necked

Stilts, American Avocets, White-faced Ibis, Forster's Tern, Wilson's Phalarope, and Cinnamon Teal.

Inundation should occur during period of high spring runoff in the Jordan River and from the North Canyon water conveyance feature. High flows in the Jordan River can overtop the existing berm along the Jordan River and inundate all or parts of the three habitat types in the Evaporative Basins MAs. Construction of diversion structures along the berm, and repairing the berm in certain locations, would allow water to enter the Jordan River floodplain at certain levels will provide the Manager with the ability to control water amounts entering the floodplain.

Unplanned inundation occurred in the spring of 2006, the Jordan River Water master was required to release a certain amount of water from Utah Lake, due to high spring runoff, which caused Utah Lake to reach compromise levels. Before the irrigation season began (roughly late March though early summer) the Jordan River flows were high enough to overtop the berm in certain areas adjacent to the Evaporative Basins MA. This caused flooding of the salt-affected floodplain and freshwater marsh habitats. In the future, if these MAs are being managed for nesting of Black-necked Stilt or American Avocet, without proposed Jordan River control-structures, flooding of nests could occur.

Timing and duration of inundation and drawdown within the Evaporative Basins MA should correspond to natural cycles of flooding and drying. All species will not have the same level of benefit from all water management scenarios. The AMP outlines future changes in management direction due to observed or recorded use of habitat features by priority bird species. Management of flooding could correspond or conversely provide high quality habitat to broad categories of drought cycles. If regional needs are found to be important for birds requiring deeper water during drought years, the Manager may want to manage for these deeper water habitats, due to lack of these habitats in other areas of the ecosystem.

Specific indications for water duration, frequency, depth, and seasonality are discussed here and can be used in conjunction with knowledge of regional needs for priority species.

Water is available for inundation and impoundment from the Mini-Jordan Channel through Kim's Junction (see Section 2.4.2), through diversion structures planned in the berm along the Jordan River, and from a very minor amount of groundwater discharge. Groundwater discharge will not be discussed, due to the uncontrolled nature of this source. The berm along the State canal will impound water within the freshwater marsh area.

The highest priority within this MA is to provide inundation to a moderate water depth (6–12 inches, or 15–30 cm; refer to HMP Chapter 3). Providing a dynamic cycle of inundation and drawdown through changing the inflow and outflow within the Evaporative Basins MA will create a diversity of water depths from shallow to deep water to increase macroinvertebrate production for foraging shorebirds. This flooding scenario will be applied during early spring through early summer (April through July) to closely mimic natural cycles of flooding and drying. Additional flooding will be required during fall (late August through November) to provide foraging and resting sites for migrating birds.

In order to provide medium-depth water (6-12 inches, or 15-30 cm) for feeding and nesting habitat, water should be diverted into the Evaporative Basins MA through Kim's Junction and the Mini-Jordan screw-gate. The flow through Kim's Junction should be allowed until desired aerial coverage is achieved, and then stopped to allow drawdown and salt concentration.

Future screw-gates along the Jordan River levee may also be used to inundate the MA and achieve desired water depths, but use of Jordan River water will be minimized due to water quality concerns. If the Jordan River reaches the top of the present berm, floodwaters would be allowed to inundate the entire Evaporative Basins MA, with the exception of a small area. If the berm is improved and screw gates are installed along the berm, water levels will be controlled by the Manager.

The optimum inundation periods for the listed priority species would be approximately March to mid-July and September through November. To most accurately mimic a natural system, the peak inundation period would occur during late May. Some shallow to medium-depth areas of inundation should be available for priority species until early fall (September). This would provide foraging habitat for the above listed species. The Jordan River floodplain would likely have been inundated during most years for this period of time, if there were no human-intervention. This inundation period would mimic the natural timing of many riparian systems in the Great Basin.

#### **4.4 ALKALINE FLATS & SLOPE WETLANDS MA**

The primary tools available for management of the Alkaline Flats & Slope Wetlands MA include irrigation and water flow-through. Factors such as soil drainage, available water capacity and hydraulic conductivity will strongly influence the water dispersion and resulting ecological changes associated with these management techniques.

The habitat types present within the Alkaline Flats & Slope Wetlands MA include upland, alkaline flats, salt meadow, short- and tall-grass prairie, deep water marsh, emergent marsh, and wet meadow. The priority bird species that will benefit most from the application of surface waters through irrigation and associated water flow-through are the grasshopper sparrow and long-billed curlew, though enhancement of upland habitat around slope wetlands.

The soils present in the Alkaline Flats & Slope Wetlands MA, where artesian wells are proposed, are mostly Arave-Saltair and Payson-Warm Springs complexes, which are classified as somewhat poorly drained soils with saturated hydraulic conductivities of 9.17 and <0.92  $\mu\text{m}$  per second, respectively. This means that some water can move through the soils in a downhill, or gravity fed manner and some areas will have surface flow and water will not infiltrate. These factors also influence surface concentration of salts and capillary action in soils. For comparison, the soils within the Riverine MA and Evaporative Basins MA are classified as very poorly drained, with a Ksat of 0.92–1.49  $\mu\text{m}$  per second. Therefore, water flow-through within the Alkaline Flats & Slope Wetlands MA may create different areas of saturated and unsaturated ground, where lack of shallow groundwater flow within the Riverine and Evaporative Basins MAs would create more pooling and less infiltration.

Irrigation will be applied through use of gated pipe as discussed in Section 3.6. Approximately 40 gpm is needed from each of these artesian wells. The number and positioning of irrigation pipes will be adjusted based upon observed aerial coverage of saturated soil conditions. Shallow groundwater levels can be observed and water flow-through estimated by installing monitoring wells, or by use of a soil probe or sharp-shooter shovel. To satisfy USACE wetland criteria, soils must be saturated within the top 12 inches for 12.5% of the growing season (23 days). Adjustments can be made to water flow rates and location of gated pipes if more or less dispersal is required.

The seasonal nature of slope wetlands naturally follows a cycle of saturation during the spring and drying out during the late summer. Irrigation from artesian wells will follow this general cycle as well. Maximum flow will be required during spring to achieve this desired result.

Natural inundation of playas and depressional wetlands within the Alkaline Flats & Slope Wetlands MA has historically occurred from intense precipitation events during winter and spring. No irrigation is planned for playas and depressional areas.

No land modifications are currently proposed. Analysis of monitoring data collected during the adaptive management period will determine if minimal land modifications are necessary to maintain overland flow and/or to promote ponding. Any excavation and berming will be minimized and avoided if possible, but a small berm may be required to detain water and control surface flows from entering adjacent MAs.

## **4.5 WET MEADOWS MA**

The primary tools available for management and benefits to priority species within the Wet Meadows MA are the same as discussed under the Alkaline Flats & Slope Wetlands MA. Artesian wells will be drilled and flow will be controlled on a seasonal basis.

## **4.6 FARMINGTON BAY MA**

The Farmington Bay MA is not currently under consideration for active management of water resources. The level in GSL and runoff from upstream areas including spring runoff will control the duration, frequency, depth and seasonality of open water or inundation within this MA. Future management actions may be taken within this MA.

## 5.0 MONITORING AND EVALUATION

### 5.1 WATER QUANTITY MONITORING PROTOCOL

Water quantity monitoring will occur throughout the LNP at discrete locations that will be used for the evaluation of existing water resources. Initial water measurements will be located at inlet to existing MAs within the LNP. Water flows leaving the site will also be measured to allow for the refinement of water budgets (Table 5; see Appendix A for a complete description of water measurement methods designed for the LNP).

Included within the monitoring site will be the Mini-Jordan, the wells at the Alkaline Flats & Slope Wetlands and Wet Meadows MAs, as well as North Canyon waters and stormwater inputs into the LNP.

**Table 5. Summary of Actions and Monitoring Required in Each MA**

MA	Actions	Monitoring
Riverine	Control water inflows from North Canyon and Mini-Jordan Inlet.	Create depth/aerial coverage relationship.
	Control water outflow at Jordan River outfall.	Determine relationship between number of boards in structure to rate of inflow.
Evaporative Basins	Control water inflows at Kim's Junction.	Create depth/aerial coverage relationship.
	Control water inflows from future Jordan River inlets.	Adjust flows once inundation levels are achieved.
Alkaline Flats & Slope Wetlands	Control water flow rates from artesian wells.	Measure aerial extent of saturated soil conditions.
	Move gated irrigation pipes.	Check for erosion and aerial coverage of sheet flows.
Wet Meadow	Control water flow rates from artesian wells.	Measure aerial extent of saturated soil conditions.
	Move gated irrigation pipes.	Check for erosion and aerial coverage of sheet flows.
Farmington Bay	No actions proposed.	N/A

#### 5.1.1 CHANNEL FLOW

Channel flow will be measured primarily within the North Canyon conveyance feature and in the Jordan River. The Jordan River flow can be obtained from the Salt Lake County gage at 500 North (<http://www.pweng.slco.org/flood/streamFlow/index.cfm>). Direct measurement of flow in the Mini-Jordan will be accomplished by first obtaining the level of water and flow rate (outflow) at the Jordan River outlet weir. The Manager will then use the correct stage-discharge

curve to relate water depth to flow rate (inflow) at the culvert for the Utah Power crossing. Specific protocols and data sheets for the measurement of water at these locations are detailed in Appendix A.

Water flow will also be controlled at the Mini-Jordan Inlet and through future screw-gates along the Jordan River. Flow rates in the A-1 Canal and Parrish/Barnard Creek can also be determined if necessary. Specific protocols have not been developed for these locations because no management actions are proposed. Field estimation of flow will be done through use of a flow meter or general measurement techniques. Where shallow, sheet, or overland flows occur in or adjacent to canals, a flow meter may not accurately measure flow rates. Measurement of width, depth, and velocity of water flows, can be used to estimate flow rates in these locations. Precipitation amount and intensity should be obtained from local weather stations and recorded in field notes or in a spreadsheet.

Channel flows will be measured frequently and during major precipitation events. Water flows will be observed year-round, with more readings occurring during the spring and summer months, to correspond with higher wildlife use periods and times of peak flows and when flows are changing relatively rapidly. The Manager should have the flexibility to take readings based upon professional judgment. Water inundation observations will also be noted and are discussed in Section 3.4. To ensure data quality control of flow monitoring, the Manager should be trained in the proper use of flow meters and field estimation techniques. Quality assurance will be checked on quarterly basis through interaction with the CDT and SAC.

Field sheets (see Appendix A) will be used for documenting channel flows at all points of diversion. Detailed field notes will also be taken to provide redundancy in records. Field observations will be compiled into a three-ring binder and entered into a database. Quarterly progress reports will be produced in coordination with bird surveys and vegetation monitoring.

Evaluation of success criteria outlined in the HMP will be used to assess trends in wildlife use, as compared to water management practices. The documentation of management changes in response to observed wildlife use will also be needed. A detailed list of management changes will be recorded in field notes and discussed in quarterly reports.

### **5.1.2 ARTESIAN WELLS**

The measurement of water amount from artesian wells will be done through direct measurement of water flows at water discharge areas using a standard bucket-fill method. The two wells will have the same protocols for measurement, but different soil types and topography may require different management action changes resulting from water dispersal and overland flow.

A flow meter will be installed at the valve on each well and will be calibrated using a standard bucket-fill method. A 5-gallon bucket can be used to estimate flow rates and volumes by recording the time needed to fill the tank. A simple calculation using volume divided by time will be used to estimate gallons/minute. For example, a 5-gallon bucket would take 8 seconds to fill at a flow rate of 40 gpm. Accuracy of flow meters will be determined at the time of well installation and may only need to be checked on a yearly basis.

The essential information needed for artesian wells is related to the number of days of saturated soil conditions in each given growing season. Soils need to be saturated within the top 12 inches for 12.5% of the growing season or approximately 23 days, measured from April 20 to October 22, to satisfy 404 permit requirements. Wetted area monitoring will be done in concert with determining the required flow rates from wells and to determine if hydrology parameters can be achieved. Flow rates may vary throughout the year and may need to be adjusted due to observed vegetation response. Measurement should occur at least weekly during the growing season and monthly outside of the growing season. Observations after spring precipitation events may be compared with shallow groundwater levels to better define the relationship of ground and surface waters within the LNP. Wetted area monitoring is discussed in Section 5.1.4.

Water flow from artesian wells will be detailed in field notes and discussed in quarterly reports. Documentation of well flow rates and soil saturation or overland flow will be essential in determining the effects of future management actions and to determine the success of wetland mitigation hydrology requirements. QC/QA of management changes resulting from flow changes will be achieved through interaction of the Manager with the CDT and the SAC.

### **5.1.3 GROUNDWATER LEVELS**

A network of shallow groundwater monitoring wells and piezometers will provide useful data on the interaction of surface water and groundwater within the LNP. Shallow monitoring wells will be installed down-slope of artesian wells to determine depth to groundwater in areas affected by flows from the wells. Well locations may need to be changed based upon observed field conditions. Monitoring wells and nested piezometers will be used to determine the apparent direction of groundwater flow in the Jordan River floodplain and slope wetland areas. Monitoring wells and piezometers should be installed along assumed shallow groundwater gradients to determine flow direction and gradients. Previous studies of ground water were completed by Forester (2006) and were used to determine placement of monitoring wells and piezometers along estimated groundwater flow lines. Shallow monitoring well placement will be determined based upon location of artesian wells.

Water levels will be recorded using a depth to water meter and recorded in field notes. Readings will be taken on the same schedule artesian flow rates in the proposed wet meadow and slope wetlands mitigation areas. Readings after precipitation events will also be taken, to better understand the relation of ground and surface waters.

Field notes will be recorded with water levels and can be entered into spreadsheets. Comparisons of shallow groundwater levels to deeper groundwater levels can be made and will determine future adaptive management. Regular entry of data into spreadsheets will occur and levels will be discussed in quarterly reports.

### **5.1.4 INUNDATION AND WETTED AREA MONITORING**

Inundation levels will be measured in the Jordan River floodplain using staff gages installed within distinct evaporative basins. Staff gages will be located to provide the LNP Manager the ability to read them from a distance using binoculars. A rating curve will be created to relate

inundation depth with aerial coverage of water. Photo points will also be used to determine relation of inundation levels to aerial coverage of certain water depths. Inundated area acreage delineated in the field with a GPS unit can be measured using GIS software. Air photos taken during high water periods and modeling area inundation may be used to determine coverage as well. Protocols may be changed due to changing field conditions and at the Manager's discretion.

Coverage will be analyzed using GIS and a rating curve can be created to relate water depth at certain staff gages to aerial coverage. This relation will need to be developed through actual field measurement of water levels and coverage.

## **5.2 WATER QUALITY/ENVIRONMENTAL MONITORING PROTOCOL**

Environmental monitoring will be used to assess the water resources that are available to the LNP. Establishing a monitoring plan is a key element in adaptive management of the LNP. The monitoring will consist of collecting appropriate samples necessary to define water and soil characteristics. The results will be used to describe the condition and status of the water resources that are available for diversion and application within the LNP. Sampling will be completed throughout the year and continue over time to determine water quality trends. This investigation will produce data necessary to compare the water quality to the standards for waters classified as 3D by the State of Utah. Development and implementation of an environmental monitoring program that supports a well-defined management plan allows for results to be relevant and useful to meeting the goals and objectives of the LNP. Careful documentation and definition of the water quality problems are important to the overall management of the water resources. Collection of appropriate data will assist in answering questions that are associated with the management of the LNP.

Baseline sampling has occurred with sampling of seasonal water trends along with some storm events as described in Section 2.3, Water Quality. Water quality sampling will expand upon this original monitoring effort to capture the contribution of new water sources (artesian wells), and record future water resource conditions (additional urban development). The overall scale of the monitoring effort will have two components, which will be the temporal and spatial scale. The temporal scale will evaluate condition over each season of the year to simulate a continuous time scale. The spatial aspect of the monitoring will evaluate the environmental factors over the nearby region, such as water that is being diverted onto the LNP versus waters that are leaving the LNP. Annual pollutant loads that are being delivered to the MAs will also be an important factor in assessment of present conditions as well as trends. The spatial scale will also include field scale monitoring, which will include sampling of water which potentially will not leave a MA as is possible with the water spreading technique planned for the artesian wells.

Three types of monitoring will be used: physical, chemical, and biological monitoring. Physical sampling will be time sensitive and sampling interval will be related to desired sampling results such as soil physical (pH, conductivity, temperature) properties after an irrigation season. Chemical monitoring (toxics, inorganic, and organics constituents) will be used to determine compliance with water quality standards.

Biological sampling could be undertaken and would be based upon macroinvertebrate life cycles when determining sampling interval. Seasonal changes or fluxes should be considered when sampling for aquatic biota. A minimum of two sampling events should be scheduled to capture a target organism's life-cycle.

Water quality sampling will be completed using techniques described below and will include the following methods.

### **5.2.1 GRAB SAMPLES**

Grab samples should be collected throughout the range of hydrologic conditions because the flow rates may affect the variability of many chemical constituents. Grab samples should also be collected, if possible, during the first 30 minutes of a storm to capture this "first flush" phenomena. The grab samples will be collected in laboratory supplied containers when ever possible being careful not to spill or washout any preservatives. The samples will be preserved and shipped according to outlined sampling procedures and QA/QC protocol will be followed. Pollutants loading on an event and annual basis will require the correlation of the flow rates occurring during the sampling event. Methods of flow measurement or estimation will follow standard methods outlined for each sampling point.

### **5.2.2 FLOW-WEIGHTED COMPOSITE SAMPLES**

A flow-weighted composite sample can be collected during a storm event at specified sites. This sample will be obtained by collecting equal volumes of water every 30 minutes (subsamples) for 3 hours. Subsamples will be combined to create one (1) composite sample for laboratory analysis. The specific fraction of each subsample to be composited will depend on the flow. The flow at the sampling site will be determined using methods described in Appendix A or other standard method that has been developed for measuring stream flow. The fraction of each subsample used in the composite will be based on the proportion of the flow rate at the sampling site during collection of that subsample to the maximum flow rate encountered. This procedure is represented by the equations below. 100% of a subsample will be used if it corresponds to the one collected when the flow rate was at the maximum.

$$V_{\text{Subsample}} = (Q_{\text{During Subsample Collection}} \div Q_{\text{Max}}) \times V_{\text{Subsample at QMax}}$$
$$S V_{\text{Subsample}} = V_{\text{Composite Sample}}$$

Where V = Volume, Q = Flow Rate, and S = Summation.

The composite sample will then be portioned into the appropriate sample containers for the specific laboratory analysis to be performed.

### **5.2.3 LABORATORY ANALYSIS**

Field measurements of TSS, pH, dissolved oxygen, specific conductance, and temperature will be taken at the time of monthly sample collection. An EPA certified laboratory will perform the water quality analyses by methods presented in Table 6 below. The samples below will be

collected on a monthly, quarterly, or yearly time interval unless results or observation warrant increasing or decreasing analysis interval.

A water quality monitoring summary will be developed to present the water quality data. The report will present the sampling and analysis methods and summarize the water quality analytical results. The report will evaluate the results as they relate to the LNP management goals and objectives.

**Table 6. Laboratory Analysis**

Parameter	Sampling Interval	Method
Metals	Semi-annually	EPA SW846 6010B
Mercury	Semi-annually	EPA SW846 7470A
Hexavalent chromium	Semi-annually	SW 7196A
Cyanide	Semi-annually	EPA SW846 9012A
Ammonia	Semi-annually	EPA 350.3
Total sulfide	Semi-annually	EPA 376.1
Phenols	Yearly	EPA 420.2
Organochlorine pesticides	Yearly	EPA SW846 8081A
Organophosphorous pesticides	Yearly	EPA SW846 8141A
PCBs (polychlorinated biphenyls)	Yearly	EPA SW846 8082
BOD (biological oxygen demand)	Monthly	EPA 405.1
Nitrate	Monthly	EPA 300.0
Total coliform	Monthly	EPA 600/8-78-017
Total phosphorous	Monthly	EPA365.2
Pentaclorophenol	Yearly	EPA SW846 8151A

Soil physical properties that are associated with the application of water within the LNP will also be sampled. The physical parameters necessary for the development of pollutant budgets would include the presence of and concentration of nutrients and cations within the upper portion of the soil profile. These constituents could come in direct contact with surface water that has been applied at the LNP and through chemical process enrich the stream flow or enrichment from the application of irrigation water may occur. Soil samples that measure the concentrations of the nutrients and cations at different soil levels may be necessary to quantify the enrichment ratios occurring within the LNP. Sample of these physical and chemical parameters will occur based upon standard soil laboratory procedures that will be outlined in a monitoring field guide.

## 5.3 EVALUATION

The monitoring of hydrologic and water quality parameters as outlined above will be used to determine the relative success of management activities. Success of management will be determined through evaluation of soil saturation and inundation levels as they relate to wildlife

use and vegetation trends. The following criteria were developed in the mitigation design for the LNP. Hydrology success criteria are discussed by MA and may change due to observed field conditions or changes in understanding of LNP ecosystems.

### **5.3.1 RIVERINE MA**

The goals of management of the Riverine MA are as follows:

- Actively restore a portion of the Jordan River floodplain by providing adequate water flow to mimic a natural Jordan River tributary and floodplain.
- Ensure that water rights and the delivery system are sufficient to enable year-round flows to the channel meander during normal climatic conditions.
- Manage channel water depth in a range from approximately six inches (15 cm) to four feet (1.2 m).

These goals will be achieved by utilizing the management actions detailed in Chapter 4. The evaluation of success in achieving the stated goals will be determined by comparing priority bird use in MAs to inundation and aerial coverage of shallow, medium, and deep-water habitats. Habitat structure was evaluated in Chapter 2 of the HMP.

### **5.3.2 EVAPORATIVE BASINS MA**

The goals of management of the Evaporative Basins MA are as follows:

- Provide appropriate ephemeral water supply to evaporative basins to support habitat diversity for shorebirds including areas for foraging, resting and nesting.

The evaluation of success in this MA will be related to priority bird use of the specific habitat types within this MA. The results of monitoring of inundation levels and aerial coverage of shallow-, medium, and deep-water habitats will be compared to actual usage of habitats.

### **5.3.3 ALKALINE FLATS & SLOPE WETLANDS MA**

The goals of management of the Evaporative Basins MA are as follows:

- Drill wells in existing uplands to obtain sufficient artesian flow to develop and maintain approximately twelve acres of slope wetlands.
- Keep modified hydrology (artesian flow) isolated from other wetland areas

The evaluation of success in this MA will be related to aerial extent of saturated soil conditions within the areas affected by artesian flows. Careful observation of surface and shallow groundwater dynamics will be used to determine extent and seasonality of saturation.

### **5.3.4 WET MEADOWS MA**

The goals of management of the Evaporative Basins MA are as follows:

- Restore historic supplemental hydrology (irrigation has ceased due to a new housing development east of the Parkway), sufficient to maintain a high-functioning seasonal/semi-permanent freshwater wetland complex.

The evaluation of success in this MA will be the same as in the Alkaline Flats & Slope Wetlands MA.

### **5.3.5 FARMINGTON BAY MA**

There are no identified management actions to evaluate.

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